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JOURNAL OF PALEONTOLOGY, VOL. 8, NO. 3, PP. 259-263, PL. 36, SEPTEMBER, 1934

SOME NEW MESOZOIC MOLLUSCA FROM THE ROCKY MOUNTAIN REGION AND ARIZONA

JUNIUS HENDERSON
(Contribution from University of Colorado Museum)

ABSTRACT

Nine species of fossil Mollusca, two from the Triassic of Arizona and seven from the Cretaceous of Montana, Wyoming, and Colorado, are described and figured as new.

DESCRIPTION OF SPECIES

UNIO THOMASI Henderson, n. sp.

Plate 36, figures 2*a–d*

Shell subquadrangular, inflated. Dorsal and ventral margins approximately parallel, but both gently rounded. Anterior end very little produced, rather narrowly rounded, then swinging by an even curve into the ventral margin. Posterior end obliquely but not angularly truncated, narrowly rounding into the ventral margin. Umbones nearly terminal, prominent, raised well above the hinge line, slightly flattened laterally. A subflattened area on sides of valves obscurely bounded above by a well-rounded ridge extending from the umbones to the postero-ventral margin. As the specimens at hand consist almost wholly of crystallized calcium carbonate, it has been impracticable to ascertain the character of the hinge, muscle scars, beak sculpture and pallial line, hence it seems best to place it in the old catch-all genus *Unio*. Surface sculpture consists only of growth lines and obscure, irregular, concentric folds such as are frequently found on heavy-shelled Unionidae. This species seems closely related to *Unio cristonensis* Meek, from the Triassic of New Mexico and other localities in the Southwestern States. The latter, however, is more elongate and the beaks less decidedly terminal than in *U. thomasi*.

Type, from Triassic strata near Seven Springs, Apache County, Arizona, Univ. of Colo. Museum, No. 10370-A: Length 30 mm., height 34.5 mm., convexity 30 mm. This and paratypes obtained by Mr. R. K. Thomas.

UNIO ARIZONENSIS Henderson, n. sp.

Plate 36, figures 7*a*, *b*

Shell elongate, narrow, suboval, in outline somewhat like some specimens of the recent *Elliptio dilatata* (Raf.) of Indiana, and even more like some specimens of the living circumpolar *Margaritifera margaritifera* Linn. Dorsal and ventral slopes approximately parallel. Dorsal margin sloping at first gently behind the beaks, then more rapidly into the posterior end. Anterior end produced, broadly rounded. Posterior end more narrowly rounded, the greatest backward extension below the middle. Ventral margin nearly straight in some specimens, broadly emarginate in others, the difference perhaps being sexual. Umbones subterminal, raised well above the hinge-line, flattened laterally, from which flattening a broad, shallow depression extends to the ventral margin, widening as it passes downward, especially well-marked in specimens with emarginate

ventral margins. Hinge and interior of the shell unascertainable because of the condition in which these fossils were when found. Sculpture consists only of growth lines and very obscure, irregular, concentric folds such as are to be seen on many heavy-shelled Unionidae.

Type, from Triassic strata in Apache County, Arizona, Univ. of Colo. Museum, No. 11306-A: Length 75 mm., height 33 mm., convexity 22 mm. Paratype from same lot, No. 11306-B: Length 70 mm., height 32 mm., convexity 19 mm. These and other paratypes were obtained by Mr. R. K. Thomas, all highly crystallized. Another lot, in more advanced state of crystallization, obtained by Prof. I. A. Keyte 1 mile north of Wingate, New Mexico, appears to be this species.

PEDALION WYOMINGENSIS Henderson, n. sp.
Plate 36, figures 5*a*, *b*

Shell of moderate size, compressed, broadly ovate. Test rather thin. Hinge straight, oblique, forming an angle of 70 to 80° with the anterior margin, casts bearing numerous pits along the hinge line which are considerably wider than the intervening ridges. Beaks terminal, bending forward beyond the anterior margin, broken from most of the specimens I have seen. Anterior margin below the forward bend of the beaks straight for some distance, then swinging gently into the ventral margin. Posterior margin swinging by a long, even curve from the end of the hinge to the rounded ventral margin. No specimen at hand shows the complete outline of the shell.

Type from the Frontier Cretaceous sandstone, Twin Creek, above Derby Dome, near Lander, Wyoming, Univ. of Colo. Museum, No. 11563-A: Height 85 mm. (broken, probably 95 mm. when complete), length 60 mm., convexity 26 mm. This and the figured specimens and other paratypes, as well as specimens in Colorado College Geological Museum at Colorado Springs, were obtained by Prof. I. A. Keyte and his assistants.

CRASSATELLITES (or CRASSATELLA) ANDREWSI Henderson, n. sp.
Plate 36, figures 6*a–d*

Shell of moderate size, subtriangular, more or less excavated in front of the beaks. Postero-dorsal margin nearly straight. Posterior end obliquely truncated, forming an angle of 85 to 90° with the ventral margin. Anterior end narrowly rounded, then swinging by a more gentle curve into the ventral margin. Ventral margin usually nearly straight, but with a tendency toward convexity in mature examples. Umbones prominent, raised well above the hinge, situated about one-fourth the distance from the anterior end. Angle of divergence of dorsal and anterior margins 90 to 92°. Lunule oval, deeply excavated, sharply defined. Escutcheon long, oval, deep and usually well-defined. Surface of valves covered with numerous, strong, semiregular, rounded ridges, mostly of about the same width as the grooves between them. Interior ventral margins armed with closely-set, strong, interlocking teeth, which are plainly exhibited externally on some specimens. Hinge, muscle scars and pallial line not known. This species is quite distinct from the one from approximately the same horizon in Huerfano Park, Colorado, *C. excavata* (Stanton). It is more nearly related to *C. cimarronensis* (White), from which it differs especially in its more nearly triangular outline and the more acute angle of divergence of the dorsal and anterior margins. It is much less inflated and longer in proportion to its height than the recently described *C. wyomingensis* Sidwell, and the posterior end is more distinctly truncated. In outline and sculpture it is suggestive of *Astarte conradiana* Whiteaves, but is more decidedly triangular and more distinctly angled posteriorly.

Type, from the Frontier (upper Benton) Cretaceous, 21 to 22 miles southeast of Lander, Wyoming, on the Haley road, Univ. of Colo. Museum, No. 10677-A: Length 29.5 mm., height 24 mm., con-

vexity 14.5 mm. It is named in honor of Mr. Philip Andrews, who first called it to my attention many years ago. It is abundant at the type locality, associated with *Camptonectes platessa* White, *Ostrea sannionis* White, *Liopistha* sp., cf. *L. meeki* White, *Anatina lineata* Stanton(?), *Turritella whitei* Stanton and other fossils. It was also obtained 6 miles northwest of Cumberland, Wyoming, by Mr. D. F. Higgins.

Stewart, (*Acad. Nat. Sci. Philadelphia, Special Pub.* No. 3, pp. 134–136, 1930) has presented a very strong argument for the use of *Crassatella*, instead of *Crassatellites*, as the name of this genus.

CRASSATELLITES (or CRASSATELLA) HENDRICKSONI Henderson, n. sp.

Plate 36, figures 9*a*, *b*

Shell oblong, truncated anteriorly, rounding narrowly into the anterior margin. Posterior margin gently rounded from the dorsal margin, then more abruptly rounding into the ventral margin. Greatest extension of the shell both anteriorly and posteriorly below the middle. Dorsal margin straight or very slightly convex, approximately parallel with the ventral margin, which is slightly convex. Umbones nearly terminal, extending but little above the hinge, but in some examples slightly overhanging the anterior margin. Angle of divergence of the dorsal and anterior margins about 100 to 110°. Lunule and escutcheon both apparently narrow, shallow and not well-defined. Surface of valves covered with fine growth lines and rather sharp, irregular, not well-marked concentric ridges, crossed toward the ventral and postero-ventral margins by obscure radiating ribs, which do not show on many specimens. Interior ventral margin armed with coarse, obscure teeth. Hinge, muscle scars and pallial line unknown. This species differs from *C. cimarronensis* (White) in its greater length in proportion to height, less angular postero-dorsal margin, slightly more produced anterior end and less pronounced sculpture.

Type, from "Colorado shale, about 1,300 feet above base," sec. 16, T. 15 N., R. 69 E., 66 miles east of Lewiston, Montana (Victor J. Hendrickson), Univ. of Colo. Museum, No. 13494-A: Length 34 mm., height 22.5 mm., convexity 17 mm. Paratype, No. 13494-B: Length 35 mm., height 30.5 mm., convexity 19 mm. Attached to a number of specimens are inarticulate *Crania*-like brachiopods.

PACHYMYA? AURANDI Henderson, n. sp.

Plate 36, figures 4*a*, *b*, 8

Shell oblong, moderately inflated. Dorsal and ventral margins slightly converging toward posterior end. Antero-dorsal margin sloping rapidly into the evenly rounded anterior end. Postero-dorsal margin straight, sloping gently toward posterior end, which is obliquely subangularly truncated, passing by a short curve into the ventral margin, which is gently and evenly rounded. Umbones about one-third of the distance from the anterior end, prominent, raised above the hinge line, obscurely flattened laterally, their prominence accentuated anteriorly by a small but well-developed lunule. Escutcheon long, narrow, bounded by a raised line. Postero-dorsal slope flattened, bounded below by a rounded ridge. Surface of valves smooth except for growth lines. Hinge, muscle scars, pallial line and other generic and specific characters unknown, hence assigned to this genus with much hesitation. This species has been long known, but remained undescribed because of the uncertainty as to its systematic position. It differs from *Pachymya herseyi* White, from the Fox Hills Cretaceous, in its less elongate form, less pronounced posterior ridge and the lack of a posterior wing.

Type, from Pierre Cretaceous, Niobrara County, Wyoming (Harry A. Aurand), Univ. of Colo. Museum, No. 17839-A: Length 20 mm., height 12 mm., convexity 9 mm. This is the only specimen I have seen retaining practically all of the shell. Other examples (casts) are 30 mm. in length. We have it from the

Hygiene group, Pierre Cretaceous, at Fossil Ridge, south of Fort Collins, from near Round Butte, north of Wellington, Colorado, and from the Bearpaw shale, about 5 miles northwest of Musselshell, Montana.

PSEUDOMELANIA HENDRICKSONI Henderson, n. sp.

Plate 36, figures 1*a–c*

Shell imperforate, acutely conical, of medium size. Whorls about eight, flattened or very slightly convex, slightly shouldered above, especially the last one, smooth, polished in one well-preserved fragment. Suture moderately impressed. Growth lines faint, bending strongly forward on the periphery of the last whorl, then backward so as to meet the columella at almost right angle. Inner and outer lips simple, bearing no ridges or folds. Aperture ovate, angular above, narrowly rounded below.

Type specimen, from the Mosby sandstone, Benton Cretaceous, Fergus County, Montana (Victor J. Hendrickson), Univ. of Colo. Museum, No. 13526-B: Length 27 mm., with about 5 mm. broken from the apex, width at periphery of last whorl 13 mm., apical angle 25 to 27°.

HAYDENIA STANTONI Henderson, n. sp.

Plate 36, figures 10*a–c*

Closely allied to *Haydenia impressa* Gabb, but larger and spire more elevated. Whorls about four, the earlier ones almost immersed in the last. There is a broad, shallow spiral sulcus below the middle of the last whorl, defined below by a ridge. Growth lines flex slightly backward across the sulcus, then forward over the bounding ridge, then sharply backward to the base, where they are at right angle with the longitudinal axis of the shell. Outer lip not thickened, ascending the last whorl. No columellar plaits exhibited on any specimens at hand, and no impressed revolving lines on the lower half of the last whorl such as are found in *H. impressa*, but our material is all imperfect.

Type, the only specimen we have showing much of the shell, from the Milliken sandstone, Fox Hills Cretaceous, near Brush, Colorado, Univ. of Colo. Museum, No. 12943: Length 32 mm., with apex eroded, width 19 mm. The largest example I have seen, designated a paratype, No. 1935-A, is 41 mm. long and 23.5 mm. wide. Numerous examples from the same horizon, at Wildcat Mound, White Rock, bluffs southeast of Windsor, northeast of Hillsboro, southeast of Hardin and northeast of Wellington, all in northeastern Colorado, show considerable variation in elevation of spire and relation of length to width. They are more or less distorted natural casts.

GONIOBASIS WELDENSIS Henderson, n. sp.

Plate 36, figures 3*a–d*

Shell narrowly subovate, spire conical. Whorls about seven, more or less convex, somewhat angular at the periphery, flattened above the periphery, slightly shoul-

EXPLANATION OF PLATE 36

FIGS. 1*a–c*—*Pseudomelania hendricksoni* Henderson, n. sp., 1*a* and 1*c*, types, about ×1.75; 1*b*, juvenile, showing upper whorls. (p. 262)

2*a–d*—*Unio thomasi* Henderson, n. sp., 2*a* and 2*d*, type, about ×1.3. (p. 259)

3*a–d*—*Goniobasis weldensis* Henderson, n. sp., 3*c*, type, about ×1.75. (p. 262)

4*a*, *b*—*Pachymya? aurandi* Henderson, n. sp., type, about ×1.75. (p. 261)

5*a*, *b*—*Pedalion wyomingensis* Henderson, n. sp., about ×0.6. (p. 260)

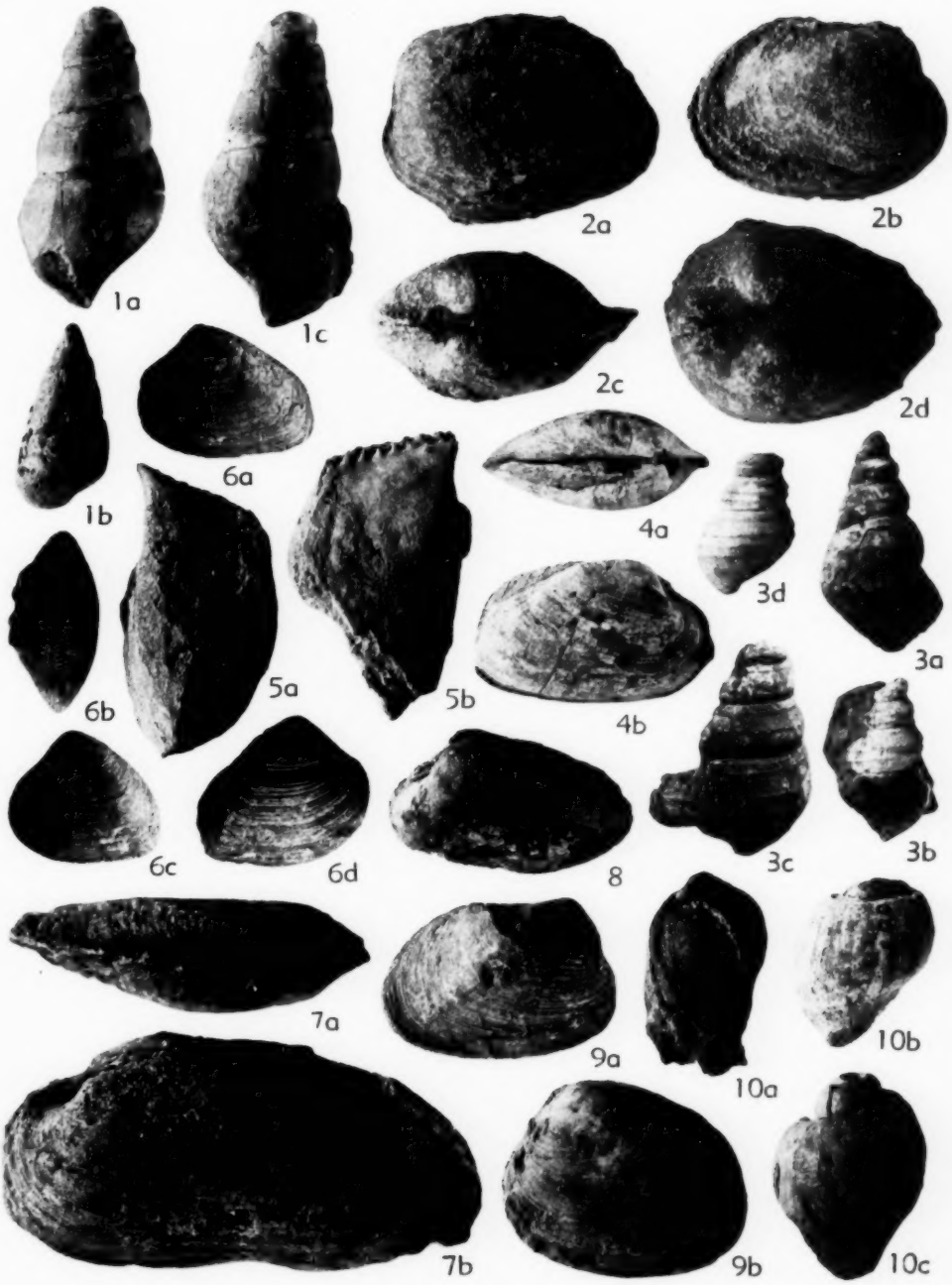
6*a–d*—*Crassatellites* (or *Crassatella*) *andrewsi* Henderson, n. sp., 6*d*, type, about ×0.9. (p. 260)

7*a*, *b*—*Unio arizonensis* Henderson, n. sp., type, about ×0.9. (p 259)

8—*Pachymya? aurandi* from Hygiene sandstone, Fossil Ridge, Colorado, about ×1.1. (p. 261)

9*a*, *b*—*Crassatellites* (or *Crassatella*) *hendricksoni* Henderson, n. sp., 9*a*, type, about ×1. (p. 261)

10*a–c*—*Haydenia stantoni* Henderson, n. sp., 10*a*, type, about ×0.9. (p. 262)



Henderson, Mesozoic Mollusca

OHIO STATE

dered at the suture. Suture very deeply impressed, channeled in some examples. Growth lines on well-preserved examples rather coarse. Two prominent carinae at the periphery and one nearly as prominent below. Every specimen examined in a large lot exhibits another well-developed carina in the upper part of the flattened area above the periphery, and in a few examples a less developed one appears above that one. A few fine obscure striae occupy the intercarinal spaces and the base of many examples. Aperture about one-third the total length of the shell, ovate, angular above, rounded below. Apex broken from all specimens.

Type (fig. 3*c*, one of the largest examples), length 16.5 mm. (original length probably about 22 or 23 mm.); width at widest part of last whorl 8.5 mm.

Laramie Cretaceous, a mile or two east of Fosston, Weld County, Colorado, abundant in a thin, iron-stained bed closely associated with beds composed largely of *Corbicula*. A few scattered valves of *Corbicula* included in the same bed with the *Goniobasis* somewhat shake one's faith in the reference of this species to *Goniobasis*. It may be nearer to *Melania*. However, it appears to be closely related to the Fort Union Eocene freshwater species, *G. tenuicarinata* (Meek and Hayden), which has been (probably erroneously) reported from the Laramie of northeastern Colorado. The strong carina which occurs in the upper part of the flattened area above the periphery on all our specimens could hardly have been overlooked by Meek and Hayden if it occurs in their species. They do not mention it, it is not shown in their figures, and does not appear on the only authentic specimen of their species that I have seen, which was received from the U. S. National Museum through the courtesy of Dr. John B. Reeside, Jr. Furthermore, *tenuicarinata* was described from a very much higher geological horizon than the *weldensis* beds, and the localities are far removed geographically. *G. weldensis* bears a superficial resemblance to *Cassiopella turricula* (White) from the Black Buttes Cretaceous, but it is not "distinctly umbilicate," as in that genus, and the periphery is not as angular.

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NEW SPECIES OF PLIOCENE MOLLUSCA FROM EASTERN OREGON

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ABSTRACT

A Pliocene fresh-water fauna is described from eastern Oregon. It is especially interesting in connection with Dall's "Balkan Fauna." One genus (*Platytaphius*), represented by two species, was heretofore known only from Lake Titicaca, in the Andes. In all, thirteen species are included, of which eight are new and are figured.

Most of the species described herein were obtained from a rather coarse, somewhat crumbly sandstone, several feet thick, consisting mostly of quartz grains with many small fragments of basalt, in the bottom of a ravine said to be known locally as Sand Hollow, about 16 miles southwest of Vale, Malheur County, Oregon, near Double Mountain. Pliocene beds containing fossil plant and animal remains occur in the region, and though the relation of the deposit in question to the surrounding formation has not been definitely ascertained, there seems very little doubt that they are of the same age. There is no reason apparent for supposing the deposit to be pre-Pliocene, and Pleistocene age is almost certainly precluded by the presence of one genus (*Payettia*) which has never been found living anywhere; another genus or subgenus (*Platytaphius*) which has been found only in Lake Titicaca, in the South American Andes, so far as we have ascertained; and the fact that nearly all of the species are apparently extinct. This fauna is especially interesting in connection with Dall's "Balkan Fauna," described from the Snake River Valley, Idaho.[1]

The deposit is probably of fluviatile origin. Early writers on western geology considered nearly all fresh-water deposits of the Rocky Mountain region lacustrine, but now it is known that most of them are fluviatile. The presence of *Anodonta* is interesting. White, in 1883,[2] stated that lacustrine waters form a more congenial habitat for *Anodonta* than do fluviatile waters, and that no *Anodonta* had been found in any of the

[1] Dall, W. H., Discovery of a Balkan fresh-water fauna in the Idaho formation of Snake River Valley, Idaho: *U. S. Geol. Survey, Prof. Paper* 132–G., pp. 109–115, 1924. Since this manuscript was sent to the printer, we received from Professor H. M. Tucker a small collection obtained at Oreana, Owyhee County, Idaho, including *Sphaerium malheurensis*, *Payettia malheurensis*, and *Platytaphius malheurensis* of this fauna, associated with *Goniobasis taylori*, *Lithoglyphus antiguus*, *Orygoceras tuba*, and *O. idahoense* of Dall's Balkan fauna.

[2] White, A review of the nonmarine fossil Mollusca of North America: *U. S. Geol. Survey*, 3rd Ann. Rept., (for 1881–1882), p. 429.

great fresh-water deposits of western North America which he then considered lacustrine. However, *Anodonta* is often found living in small, sluggish streams and in small ponds such as occur in the valleys of rivers. Since White's publication several species of the genus have been described from Tertiary deposits of the Pacific states, and I have found *A. californiensis* Lea in a Pleistocene deposit in Grand Coulee, Washington. The post-Cretaceous history of western nonmarine Mollusca has been recently discussed[3] and needs not be repeated here.

The genus *Goniobasis*, represented abundantly by living species in the eastern United States and by a number of living species in western Oregon, western Washington and California, and by Eocene species in the Rocky Mountain region, is not found living in Idaho and eastern Oregon. In the Balkan fauna Dall transferred *Melania taylori* Gabb to *Goniobasis* and described a variety *calkinsi*. Though probably they are not *Melania*, it is doubtful whether they are *Goniobasis*. Perhaps it would have been as well to leave them in *Pachychilus*, where Hannibal placed them.[4]

DESCRIPTION OF SPECIES

MARGARITIFERA MARGARITIFERA (Linnaeus)

Two specimens of this circumpolar species were found in the Pliocene deposit 16 miles southwest of Vale, Oregon. Also we have this species, Pliocene or Pleistocene, obtained by Prof. Orma J. Smith, from 20 miles southwest of Caldwell, and east of Given's Hot Springs, Owyhee County, Idaho. Probably this material is all the living western color form, *M. m. falcata* (Gould), but as the interior cannot be seen and the color of the nacre would doubtless have faded, there is no way of ascertaining whether it was purple.

ANODONTA MALHEURENSIS
Henderson and Rodeck, n. sp.
Plate 37, figures 1*a*, *b*

Shell of medium size, much compressed, flat-sided, suboblong, the diagonal posterior swing of the postero-dorsal and the antero-ventral margins giving it a strong tendency toward a rhombic outline; dorsal and ventral margins nearly, but not quite, straight and parallel; beaks raised but little above the hingeline; umbones not inflated, sculptured by numerous small, sharp, concentric riblets, which are rather straight below but turn upward somewhat abruptly before and behind; growth lines minute, paralleling a few low, rounded, irregular, concentric undulations; anterior end rather evenly and somewhat narrowly rounded to a little below the middle, thence rounding by a broader curve into the ventral margin; posterior end diagonally truncated nearly to the ventral margin, into which it swings by an abrupt, narrow curve. Unlike the living forms of the region, *A. californiensis* Lea, *A. nuttalliana* Lea, *A. wahlamettensis* Lea and *A. oregonensis* Lea, *A. malheurensis* exhibits no posterior angle or wing. The hinge has not been directly observed, but natural casts show no evidence of dentition.

Type, No. 18041a, in the Univ. of Colo. Museum, length 47 mm., height 29 mm., diameter 12 mm. Paratype, No.

[3] Henderson, Junius, Molluscan provinces in the western United States: *Univ. of Colorado Studies*, vol. 18, pp. 177–186, 1931.

[4] Hannibal, *Proc. Mal. Soc. London*, vol. 10, pp. 182, 201, 1912.

18041b, length 51 mm., height 30 mm., diameter 12 mm. Largest specimen found, mostly exfoliated, length 71 mm., height 37 mm., diameter 15 mm.

Pliocene, 16 miles southwest of Vale, Malheur County, Oregon.

SPHAERIUM MALHEURENSE
Henderson and Rodeck, n. sp.

Plate 37, figures 2*a–c*

Shell large, inflated, moderately thin in proportion to its size, almost equilateral, subrotund, nearly equally rounded at both ends, but posteriorly slightly narrower and more prolonged just below the middle; ventral margin broadly, evenly rounded; hinge line arcuate; umbones swollen and elevated far above the hinge line; beaks turned forward so as to meet the hinge line a little in advance of the middle; umbones sculptured by many sharp, regular, concentric ridges (remarkably prominent in some of the paratypes), which pass into a few low, rounded undulations between the umbones and the ventral margin, these not showing on the interior of the valves.

Type, a well-preserved right valve, No. 18042a, in Univ. of Colo. Museum, length 24 mm., height 20.5 mm., height from ventral margin to hinge 17 mm., convexity of valve 8 mm. (convexity of both valves in place would be 16 mm.). Paratypes, imperfect valves, No. 18042, in Univ. of Colo. Museum. Pliocene, 16 miles southwest of Vale, Oregon.

The large size suggests *Corbicula* or *Cyrena*, but the thin shell and hinge characters clearly place it in *Sphaerium*. The pallial line has not been detected.

Compared with *S. idahoense* Meek,[5] *S. malheurense* is more nearly equilateral, less disposed toward a triangular outline, and has more inflated and elevated umbones. Some casts of *idahoense* "show a few distinct, broad, irregular, concentric undulations that were doubtless more strongly defined on the exterior of the valves," but the external undulations of *malheurense* do not show on the interior of the valves, hence would not show on casts.

The large Quaternary *Sphaerium pilsbryanum* Sterki (Nautilus, vol. 22, p. 141, 1909), from Bear Lake, Utah-Idaho, is quite distinct. It is considerably smaller, less inflated, more inclined toward a triangular outline, the posterior margin is obliquely truncated, the postero-ventral margin is subangulate, and the umbones are not elevated as far above the hinge.

PISIDIUM species undetermined

A number of detached valves of *Pisidium* occur in the deposit 16 miles southwest of Vale, Oregon, but probably no description of them would be recognizable if the same form should be found elsewhere in a different state of preservation, so it seems useless to designate them by a name.

FLUMINICOLA MALHEURENSIS
Henderson and Rodeck, n. sp.

Plate 37, figures 8*a*, *b*

Shell of medium size for this genus, smooth, helicoid, imperforate, somewhat similar to *F. fusca* (Haldeman), but spire decidedly shorter; whorls four and one-half to five, rounded, closely coiled, the

[5] The original locality of *S. idahoense* and some associated fossils was given as Fossil Hill, Kaw-soh Mountains, Nevada, and in the "same formation at Castle Creek, Idaho," Meek, Rept. King's U. S. Geol. Explor. of 40th Parallel, vol. 4, pp. 183–184, pl. 16, fig. 1, 1877. Dall says that Meek's "locality was later included in the State of Idaho," and Castle Creek is the locality in which Dall's Balkan fauna was obtained (Dall, U. S. Geol. Survey, Prof. Paper 132–G, p. 110, 1924) which apparently came "from the same beds that yielded the Pliocene or Pleistocene vertebrate fauna referred to by Merriam" [Merriam, Bull. Univ. Calif. Dept. Geol., vol. 10, p, 432, 1917]. Dr. John B. Reeside, of the U. S. Geol. Survey has recently called our attention to several statements in the early reports which, taken together, indicate that the locality is south of the Montezuma (called Trinity in many modern maps) Range, in Ts. 23, 24, Rs. 27, 28, southwest of Humboldt Lake and west of Carson Sink, Nevada, a long way from Idaho.

last not descending much toward the aperture and sometimes flattened above the periphery; suture well impressed; aperture subovate; peristome simple, its ends joined by a heavy callus; sculpture consists of fine growth lines only. This species is readily distinguished from its apparently nearest relative by its much shorter spire, though, as is usual in the genus, it varies somewhat in this respect. Type, No. 18044a, in Univ. of Colo Museum, altitude 8.5 mm., diameter 7.5 mm.

Pliocene, about 16 miles southwest of Vale, Malheur County, Oregon. We have casts probably of the same species, from 20 miles southwest of Vale, Oregon.

VORTICIFEX TRYONI Meek?

Three small specimens from the deposit 16 miles southwest of Vale, Oregon, are very doubtfully referred to *V. tryoni*, perhaps the variety *concava* Meek (if that form should be recognized), as the spire is depressed slightly below the top of the body whorl.

VORTICIFEX? sp.

In the deposit 16 miles southwest of Vale, Oregon, imperfect, badly crushed fragments of a very thin-shelled species of gastropod are common, but have not been determined, even generically. Above, they look much like a flat *Carinifex*. The base is somewhat like that of *Vorticifex stearnsii* White. They cannot be referred plausibly to any genus because of their imperfection.

PAYETTIA (?) MALHEURENSIS

Henderson and Rodeck, n. sp.

Plate 37, figures 5*a–d*

Fifteen specimens from the deposit 16 miles southwest of Vale, Oregon, are referred to this genus with some uncertainty. In all but one specimen the left lateral margins are much straighter than in *P. dalli*, forming a narrower shell with more nearly parallel sides. The vertex is lateral, proceeding from the left posterior portion of the shell, and shows a volution of about one turn toward the right posterior. The beak is not produced as in *dalli* but is closely appressed to the shell. There is no more than a trace of a posterior septum within, such as is found in *P. dalli*, and which is elaborated in *Latia*. These not well preserved and perhaps juvenile fossils are all small, 7 mm. or less in length, as compared with the dimensions of 16 by 10 mm. as given by White for *P. dalli*. The exterior of the shells shows the concentric undulations very much less conspicuous than in *dalli*. Type, No. 18045a, Univ. of Colo. Museum, length 7.5 mm., width 4.5 mm., altitude 3.25 mm. Pliocene, 16 miles southwest of Vale, Oregon.

With the exception of the internal septum these specimens fit into the genus *Latia*. *Amphigyra*, with a septum at all stages of growth, and *Gundlachia*, with a septum in the second stage, are close, but the present specimens seem to be excluded from them. It seems best to include the species tentatively in the genus *Payettia*, from the same region, although it may be found to represent a new genus.

Specimens of *P. dalli* in the University of Colorado Museum, obtained 2½ miles southeast of Hammett, Idaho, received from C. Francis Miller, measure 14 mm. in length. An internal view of one of them is presented (Pl. 37, fig. 7) to show the *Crepidula*-like deck posteriorly. These specimens were associated with *Goniobasis taylori* (Gabb), *Lithoglyphus antiquus* (Gabb), *L. campbelli* Dall, and *Sphaerium idahoense* Meek.

LYMNAEA species undetermined

Plate 37, figure 10

Two rather large specimens of *Lymnaea*, much too imperfect for satisfactory identification or description, were found at the locality 16 miles southwest of Vale. They resemble somewhat *L. meekii* Evans and Shumard, from the White River group, but probably belong to an undescribed species.

MENETUS PLANULATOIDES
Henderson and Rodeck, n. sp.

Plate 37, figures 4*a–c*

Shell small, flat above, rounded below, somewhat similar to *M. planulatus* (Cooper),[6] a living species of Oregon and Washington, but the umbilicus is very small. Apex slightly sunken. The carina or angle at the edge of the upper flat surface is well marked, from which the shell rounds evenly to the base, then near the middle of the base rounds abruptly into the umbilicus. The widest part of the shell is at or near the angle. Growth lines scarcely visible. Shell shows some tendency toward developing one or more spiral ridges on the base, as in some specimens of *planulatus*. Width 3.25 mm., height 1.5 mm. Type, No. 18050a, Univ. of Colo. Museum.

Pliocene, 16 miles southwest of Vale, Oregon.

[6] For discussion of *M. planulatus* see Henderson, Junius, Nonmarine Mollusca of Oregon and Washington: *Univ. of Colo. Studies*, vol. 17, pp. 140–141, 1929.

PLATYTAPHIUS Pilsbry and Vanatta

This name was proposed (Pilsbry and Vanatta, *Proc. Acad. Nat. Sci Phila* vol. 76, p. 51, 1924) as a section of *Planorbis* to accommodate *Planorbis heteropleurus* Pilsbry and Vanatta (*Proc. Acad. Nat. Sci. Phila.*, for 1896, p. 562), a living species of Lake Titicaca, in South America. It is so distinct that it might be better to consider it a genus.

PLATYTAPHIUS MALHEURENSIS
Henderson and Rodeck, n. sp.

Plate 37, figures 9*a–c*

Shell rather small, solid, depressed broadly convex above, apex slightly sunken, broadly concave below, the concavity passing into a small funnel-like umbilicus in the middle. Whorls three and one-half or four, the last proportionately very large, embracing nearly all of the earlier whorls, marked only by minute growth lines. The last whorl is narrowly rounded, not angled or carinated above as it is in *P. heteropleurus*, thence it rounds broadly to the periphery,

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EXPLANATION OF PLATE 37

FIGS. 1*a*, *b*—*Anodonta malheurensis* Henderson and Rodeck, n. sp., type, slightly enlarged. (p. 265)

2*a–c*—*Sphaerium malheurense* Henderson and Rodeck, n. sp., type, slightly enlarged. (p. 266)

3*a–c*—*Carinifex* (?) *malheurensis* Henderson and Rodeck, n. sp., 3*a*, type, slightly enlarged. (p. 268)

4*a–c*—*Menetus planulatoides* Henderson and Rodeck, n. sp., 4*b*, type, about ×3. (p. 268)

5*a–d*—*Payettia* (?) *malheurensis* Henderson and Rodeck, n. sp., 5*d*, type, about ×3. (p. 267)

6*a–c*—*Platytaphius milleri* Henderson and Rodeck, n. sp., 6*a*, type, slightly less than ×3. (p. 268)

7—*Payettia dalli* (White), somewhat less than ×3.

8*a*, *b*—*Fluminicola malheurensis* Henderson and Rodeck, n. sp., 8*a*, type, about ×3½. (p. 266)

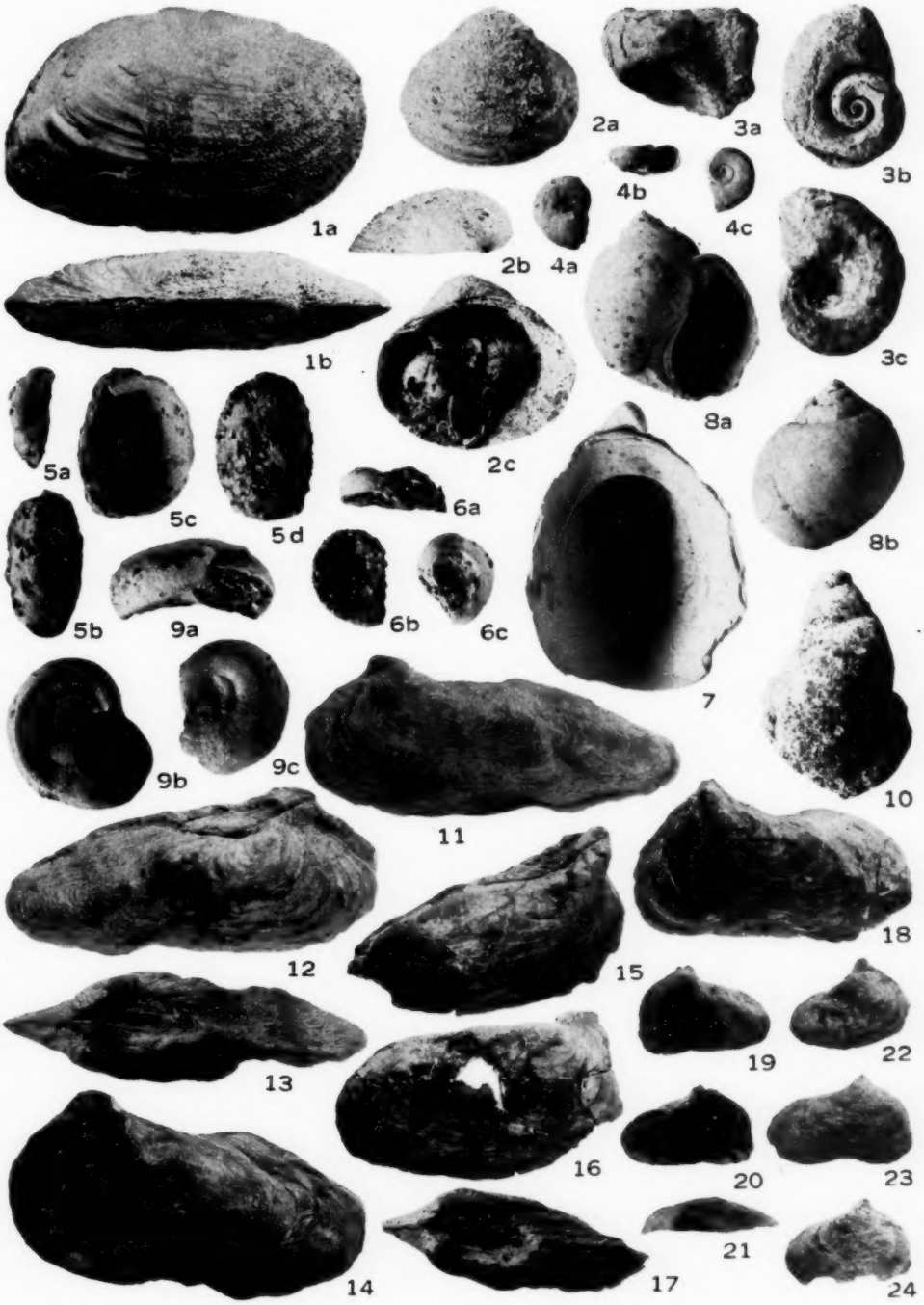
9*a–c*—*Platytaphius malheurensis* Henderson and Rodeck, n. sp., 9*a*, type, somewhat less than ×3. (p. 268)

10—*Lymnaea* sp. undet., slightly enlarged. (p. 267)

11–13—*Exputens llajasensis* Clark, n. gen., n. sp., Holotype, Univ. Calif. No. 32391. (p. 270)

14–18—*Exputens llajasensis* Clark, n. sp., 14, Paratype, Univ. Calif. No. 32393. 15, Paratype, Univ. Calif. No. 32392. 16, Paratype, Univ. Calif. No. 32389. 17, 18, Paratype, Univ. Calif. No. 32390. (p. 270)

19–24—*Exputens alexi* Clark, n. sp. 19–21, Holotype, Univ. Calif. No. 32386. 22, Paratype, Univ. Calif. No. 32384. 23, Paratype, Univ. Calif. No. 32385. 24, Paratype, Univ. Calif. No. 32387. (p. 271)



Henderson and Rodeck, Pliocene Mollusca
Clark, Eocene Lamellibranchiata

which is narrowly rounded to the sharply carinated, latero-basal margin, so that the widest part of the shell is somewhat above the carina, with a rather marked depression just above the carina making it stand out as a minute but distinct ridge when examined with a lens. The whorls are flattened below, the carina forming a sharp edge, the flattened surface being so tilted as to produce the concave basal outline of the shell. Aperture very oblique, proportionately rather large. Greatest width 8.5 mm., greatest height 4.5 mm. Type, No. 18049a, paratypes No. 18049b, in Univ. of Colo. Museum.

Pliocene, 16 miles southwest of Vale, Oregon.

PLATYTAPHIUS MILLERI
Henderson and Rodeck, n. sp.

Plate 37, figures 6*a–c*

Shell smaller than *P. malheurensis*, sharply carinate above as well as on the latero-basal margin, the upper carina sharper and more marginal than in *heteropleurus*, margining a rather flat or very broadly funnel-shaped depression. Base and umbilicus similar to *malheurensis*. Type No. 18051a, Univ. of Colo. Museum. Width 5.25 mm., height 2.5 mm.

Pliocene, 16 miles southwest of Vale, Oregon.

The following, from a locality a few miles from that of the foregoing species, has been received from Mr. C. Francis Miller.

CARINIFEX (?) MALHEURENSIS
Henderson and Rodeck, n. sp.

Plate 37, figures 3*a–c*

Seven imperfect casts appear to be distinct from all described species. The spire is nearly flat, the shoulder rounded, the umbilical crater broad, defined by a high, sharp ridge, as is usual in this genus. It is more like *C. ponsonbyi* Smith than any other species, but is wider in proportion to its height and consequently the umbilical crater is wider. In *C. ponsonbyi* usually the spire is slightly elevated above the top of the last whorl, but this is not true of these casts. The absence of a shoulder carina should not prevent its assignment to this genus, as casts of some specimens of *C. ponsonbyi* and other species would exhibit but a very obtuse angulation there. The sharply-bounded, crater-like pit seems to be unmistakably that of *Carinifex*. Type, No. 18052a, in the Univ. of Colo. Museum, altitude 13.5 mm., width 19.15 mm., greatest width of umbilical pit 13.5 mm.

Pliocene, Cow Hollow, 6 miles north west of Double Mountain, 20 miles southwest of Vale, Malheur County, Oregon.

JOURNAL OF PALEONTOLOGY, VOL. 8, NO. 3, PP. 270-272, PL. 37, SEPTEMBER, 1934

A NEW GENUS AND TWO NEW SPECIES OF LAMELLIBRANCHIATA FROM THE MIDDLE EOCENE OF CALIFORNIA

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ABSTRACT

In the middle Eocene of California two species of Lamellibranchs were found which do not belong to any described species. The writer proposes the name *Exputens* for the new genus, which is placed, tentatively, in the family Pteriidae.

In working over collections from the middle Eocene of the Simi valley area, Ventura County, California, the writer's attention was called to a new species of Lamellibranchiata, the genus of which could not be determined. Later work shows that the genus is new and that the nearest living relative is the genus *Vulsella*, which has a long geological range.

The genus is named *Exputens* and is placed tentatively in the family Pteriidae. Mr. Alex Clark gave the author specimens referable to this same genus from middle Eocene beds located a few miles northwest of Coalinga, California. These specimens represent another species.

Other specimens referable to this genus are found in middle Eocene collections from the Santa Ynez Mountains. However, this material is not well enough preserved to be specifically determinable.

Family PTERIIDAE

Genus EXPUTENS Clark, n. gen.

Shell equivalved, unequilateral; inner layer with pearly structure; auriculate anteriorly; dimyarian; hinge line edentulus; the small anterior adductor scar is just below the ligamental pit, not always well defined; the larger posterior adductor scar is directly below this and is only slightly behind the beaks. The most distinctive character of the genus is the large external ligamental pit which in each valve is situated on a broad overhanging platform which resembles a chondrophore.

This genus, on account of the anterior ear, the pearly structure of the shell and the presence of two adductor muscle scars in each valve, is placed in the family Pteriidae. The outline of the shell is very different from any other genus in that group, also the lack of a posterior wing and the presence of a ligamental pit on a well defined chondrophore are quite unique characters for the family.

The nearest approach to this genus is *Vulsella* which is also very common in the European Eocene. On the latter genus there are no ears; the exposed ligamental pit is on the end of the shell and not on the side as is true of the genus *Exputens*.

EXPUTENS LLAJASENSIS Clark, n. sp.

Plate 37, figures 11–18

Shell thin, variable in outline, roughly elongate, subquadrate in outline; surface smooth except for fairly heavy, ir-

regular lines of growth; beaks in the anterior third of the shell, variable in prominence, inconspicuous on the type. Anterior ears defined and in front of the beak; ligamental area broad, triangular in outline and situated on a chondrophore-like platform which stands out almost at right angles to the main surface of the shell; posterior muscle scar large near the ventral edge and a little posterior to the beak; anterior scar small and situated below the beak and the anterior edge of the ligamental platform, obscure on some specimens.

Dimensions.—Holotype, Univ. Calif. No. 32391, length 52.8 mm., height 21.6 mm., thickness, both valves included, 15 mm.; paratype, Univ. Calif. No. 32393, length 52 mm., height 25 mm., thickness of one valve 6.6 mm., figure 14; paratype, Univ. Calif. No. 32390, length 38.6 mm., posterior margin broken, height 21.9 mm., figures 17 and 18.

Locality.—All the figured specimens came from University of California locality 7004, a branch canyon of Llajas. The branch canyon is not well shown on the map but may be recognized by the fact that it enters Llajas Canyon from the east just north of the northernmost extent of the 1,500 foot contour.

There are several distinct variants of this species as found at the type locality; the type, figures 11, 12 and 13, represents the most common one. This may be referred to as variety A; it is a perfect specimen showing both valves; it is long and narrow and has well-developed anterior ears; the beaks are only moderately conspicuous. The specimen shown in figure 14 may be considered as belonging to this variety.

Figure 16, Univ. Calif. No. 32389, represents another variant, variety B. On this specimen the beaks are so inconspicuous as to be hardly discernible. The ear is larger than on variety A and the anterior end is broadly rounded, sloping down from the outer angle of the ear almost at right angles to the posterior dorsal margin and giving a subquadrate appearance to the shell.

Figures 17 and 18 represent variety C, a form in which the beaks are conspicuous and opisthogyrous. The ear is almost obsolete; this is brought about by the fact that the upper margin of the ear slopes abruptly downward and joins the anterior edge of the shell without any break such as is seen in varieties A and B.

Figure 15, Univ. Calif. No. 32392, shows a specimen somewhat deformed by crushing. On this specimen the beaks are still more prominent than on that shown in figure 18. It may be included with the group of variety C.

Most of the specimens of this species show irregularities in the surface of the shell. This, together with the variability in outline, the general elongate shape, and the lack of any well-defined bysal notch, suggests that the species was a nestler.

The specimens were found in medium coarse sandstones, associated with a fairly large fauna, some of the most common species of which are:

Crassatellites indentata Cooper
Ostrea idriaensis Gabb
Venericardia hornii Gabb var.
Amaurellina clarki Stewart
Globularia hannibali (Dickerson)
Surculites mathewsonii (Gabb)
Volutocorbis lajollaensis (Hanna)
Aturia myrli Hanna

This fauna belongs to the Domengine horizon (middle Eocene).

EXPUTENS ALEXI Clark, n. sp.
Plate 37, figures 19–24

Shell moderately thick for the size, elongate subquadrate to subtrapezoidal in outline; beaks inconspicuous, in the anterior third of the shell; anterior end broad and bluntly rounded; posterior end narrower than anterior and regularly rounded; the anterior ear stands up prominently above the beaks as though this portion of the shell had been twisted upward and backward. A large triangular ligamental area, only moderately de-

pressed. The line of greatest convexity of the surface of the shell extends from the beak to the posterior end. The general surface of an unweathered specimen is sculptured by somewhat irregular concentric undulations. The large posterior adductor scars are close to the ventral edge and only slightly posterior to the beaks. The small anterior scars are just below the beaks and somewhat obscure on some of the specimens.

Dimensions.—Holotype, Univ. Calif. No. 32386, length 18.7 mm., height 13.1 mm., figs. 19–21; paratype, Univ. Calif. No. 32384, length 17 mm., height 12 mm., fig. 22; paratype, Univ. Calif. No. 32385, length 19 mm., height 2.8 mm., fig. 23; paratype, Univ. Calif. No. 32387, length 17.7 mm., height about 12 mm., fig. 24. In all these measurements the height was taken from the tip of the ear, which is above the beak to the ventral edge.

Locality.—Five specimens of this species were given to the writer by Alex Clark, in whose honor it is named. He reports that they came from a coarse sandstone reef, underlying and overlying shale, outcropping about 100 yards from the mouth of a small gully on the north bank of Los Gatos Creek, which is a few miles north of the town of Coalinga and in the NE. $\frac{1}{4}$, sec. 10, T. 20 S., R. 14 E., Mount Diablo base line. Here it is associated with a typical Domengine fauna.

Exputens alexi may be distinguished from *E. llajasensis* by the position of the ears, which on the former stand out above the beaks whereas on the latter they are in the normal position in front of the beaks. Another character, in which the two species differ, is the ligamental pit; on the former it is much less depressed than on the latter. Apparently *E. llajasensis* is a more variable form than *E. alexi*. None of the specimens of the latter species is as large as the average size of the former.

JOURNAL OF PALEONTOLOGY, VOL. 8, NO. 3, PP. 273-280, PL. 38, SEPTEMBER, 1934

THE GENUS *DIPLOSCHIZA* FROM THE UPPER CRETACEOUS OF ALABAMA AND TEXAS[1]

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ABSTRACT

The old genus *Diploschiza* Conrad (1866) is revived. In lieu of the original type of *Diploschiza cretacea* Conrad, which is apparently lost, specimens from the Selma chalk at Demopolis, Alabama, are selected as neotypes. A closely related smaller form from the Pecan Gap chalk member of the Taylor marl of Texas is named *Diploschiza cretacea minor*, and a radially costate form from the Selma chalk of Alabama is named *D. cretacea striata*. Because of the restricted stratigraphic range and the extended geographic range of *Diploschiza* in the Gulf region, the representatives of the genus are valuable index fossils.

The genus *Diploschiza* was proposed by T. A. Conrad in 1866[2] and in the same paper the type species, *Diploschiza cretacea* Conrad, was described. The original description is brief, the type material is apparently lost, and the occurrence of the species is given merely as the Cretaceous of Alabama. Doctor Showalter is named as the collector of the material.

Interest in this old genus is revived because of the discovery in recent years that its American representatives, so far as known, are restricted in their stratigraphic range to a narrow zone and are, therefore, useful in establishing age relationships.

Whitfield,[3] in 1885, identified a shell from the Upper Cretaceous at Upper Freehold, Monmouth County, New Jersey, as *Diploschiza cretacea* Conrad, and although he used Conrad's name formally in his systematic treatment, he questioned the validity of the genus, as follows:

> I have seen only one of the deeper valves of this species, and that has the apex broken. The features of the smaller valve are given from Mr. Conrad's figure. I can not see how the shell differs from the ordinary *Anomia*, and do not think there is the slightest need of the generic subdivision.

The New Jersey specimen appears from the figure to be a true *Anomia*, and Weller[4] later included it in the synonymy of *Anomia argentaria* Morton. Weller says:

> The shells which Whitfield has identified as *Diploschiza cretacea* Conrad, seem to be noth-

[1] Published by permission of the Director, U. S. Geological Survey.

[2] Conrad, T. A., Note on the genus *Gadus*, with descriptions of some new genera and species of American fossil shells: *Am. Jour. Conch.*, vol. 2, pp. 77, 105, pl. 9, figs. 2, 3, 1866.

[3] Whitfield, Robert P., Brachipoda and Lamellibranchiata of the Raritan clays and greensand marls of New Jersey: *U. S. Geol. Survey, Monograph*, vol. 9, p. 43, pl. 4, figs. 4–8, 1885. (*Geol. Survey of New Jersey*, Paleontology, vol. 1, p. 43, pl. 4, figs. 4–8, 1886.)

[4] Weller, Stuart, Cretaceous paleontology of New Jersey: *Geol. Survey of New Jersey*, Paleontology, vol. 4, pp. 496–499, 1907.

ing more than more strongly convex individuals of *Anomia argentaria*. There is certainly no sufficient basis for the genus *Diploschiza*, and Conrad's types of his species seem to have no characters to separate them from Morton's species.

There is nothing to indicate that either Whitfield or Weller saw the type material of *Diploschiza cretacea* and both probably based their conclusions on Conrad's figures of that species. Although Conrad figured both valves, the figures are drawings, and I suspect that the two valves belong to the same individual, and were closely attached so that their interior features could not be seen.

In 1909 I collected numerous shells of a species which appears to be *Diploschiza cretacea* Conrad from exposures of the Selma chalk, in a bluff at Demopolis, Marengo County, and at Jones Bluff, near Epes, Sumter County, Alabama. The identification is based on Conrad's original figures which are good representations of the exteriors of both valves, and of the convexity of the shell. The new material affords good views of the exterior and interior of both valves, and is clearly not referable to *Anomia;* it is apparently not referable to any genus antedating the *Diploschiza* of Conrad.

It is unfortunate that the exact type locality of *Diploschiza cretacea* was not specified. According to the record the type material was collected by Doctor Showalter. In response to an inquiry as to the whereabouts of Doctor Showalter's home, addressed to Dr. Walter B. Jones, State Geologist of Alabama, I received the following reply, dated May 4, 1933:

> We have checked through our correspondence, and find several letters from Dr. E. R. Schowalter (note the spelling), from 1874 to 1879. All of our correspondence was from either Mobile or Point Clear, the latter place being the home of one of his sons, Dr. V. M. Schowalter.
>
> It is quite evident that Schowalter lived at Uniontown for a number of years before moving to Mobile. We have in our collections a vast amount of material collected by him, from localities within the Uniontown area. His Selma chalk fossils could well have come from Uniontown, or even from Demopolis or Epes. He visited widely throughout the State, in search of fresh-water shells. Like many other scientists of the old school he collected anything he could get his hands on.

The fact that Dr. E. R. Schowalter was an invertebrate collector and lived at Uniontown affords a fair presumption that he was the "Doctor Showalter" from whom Conrad received the type material of *Diploschiza cretacea*, and this presumption is strengthened by the fact that Conrad[5] had at an earlier date received Eocene shells from a "Doctor Showalter" of Uniontown.

Uniontown is in Perry County on the Southern Railway, 19 miles east by south of Demopolis, and is approximately on the strike of the beds of the Selma chalk exposed in the bluff at Demopolis. Although the exact type locality of *Diploschiza cretacea* may never be known, the probability that it lies somewhere between

[5] Conrad, T. A., Description of new species of Cretaceous and Eocene fossils of Mississippi and Alabama: *Acad. Nat. Sci. Philadelphia, Jour.*, 2d ser., vol. 4, p. 291, 1860.

Uniontown, Perry County, and Epes, Sumter County, along the belt of outcrop of the chalk beds exposed in the bluff at Demopolis, is strong. I have therefore selected as neotypes specimens from Demopolis which appear to be essentially like the material figured by Conrad.

Diploschiza is represented in the southward extension of the Pecan Gap chalk member of the Taylor marl of Texas (formerly known in this southern area as the Marlin chalk member, a name recently abandoned) by a varietal form described below under the name *D. cretacea minor*. The term Pecan Gap chalk as here used includes the Lott chalk[6] member of the Taylor marl, which is now known to be merely the Pecan Gap chalk repeated in outcrop by faulting. The term Lott chalk is, therefore, abandoned. The variety is smaller, less rotund, and more elongated in the direction of the height than the Demopolis species. These differences are slight, but hold good for a large number of individuals from five or more localities. The Pecan Gap chalk contains an assemblage of other fossils similar to that in the chalk at Demopolis, including such forms as the brachiopod species, *Terebratulina filosa* Conrad (identified by Dr. G. A. Cooper), the serpuloid species *Hamulus onyx* Morton, and the ostreoid species, *Ostrea plumosa* Morton and *Gryphaea convexa* Morton. On the basis of *Diploschiza* and these other species the Pecan Gap chalk is correlated approximately with the chalk at Demopolis. *Diploschiza* has not as yet been found in the typical Pecan Gap chalk of northeastern Texas.

So far as known, the variety *Diploschiza cretacea minor* is confined to a zone which in general is 30 or 40 feet thick, and probably does not exceed a thickness of 100 feet. The varietal form *Diploschiza cretacea striata*, which was collected near Massillon, Dallas County, Alabama, may have come from the same, or a slightly lower, horizon in the Selma chalk than did the shells from Demopolis and Epes.

The restricted stratigraphic range of *Diploschiza*, and the ease with which it can be distinguished from all other fossils in our North American Upper Cretaceous deposits, renders it a valuable index fossil.

The shells pictured in Plate 38, with the exception of the reproductions of Conrad's original figures, were photographed by N. W. Shupe in the laboratory of the United States Geological Survey, and were retouched by Miss Frances Wieser of the same Bureau.

[6] Dane, C. H., and Stephenson, L. W., Notes on the Taylor and Navarro formations in east-central Texas: *Am. Assoc. Petroleum Geologists, Bull.*, vol. 12, pp. 52–53, 1928.

DESCRIPTION OF FOSSILS

DIPLOSCHIZA Conrad

Diploschiza CONRAD, *1866*, Am. Jour. Conch., vol. 2, pp. 77, 105.—TRYON, *1884*, Structural and systematic conchology, Mollusca, vol. 3, p. 295.—WHITFIELD, *1885*, U. S. Geol. Survey, Mon., vol. 9, p. 43.—WELLER, *1907*, New Jersey Geol. Survey, Paleontology, vol. 4, p. 498.
Type species: *Diploschiza cretacea* Conrad.

Conrad described the genus as follows: "Shell bivalve, with a deeply notched emarginate hinge in both valves; smaller valve concave; structure laminated." He assigned the genus to the Anomiidae.

The genus resembles *Anomia* in form and in the fibrous texture and the luster of the shell. The internal features, however, which Conrad apparently did not see, show that the genus does not belong in the family Anomiidae.

The shell is sessile and is attached by the right valve, the scar of attachment often covering a third or more of the surface. The umbonal portion of the shell on both valves is very thin, and is broken away on many specimens, giving the appearance of notches such as were described by Conrad as a normal feature instead of an accidental one. The shell becomes moderately thick centrally and thins again to an edge at the outer margin. The hinge is edentulus and no evidence of a resilifer has been observed on any specimen. On well preserved specimens the hinge line is straight and may reach a length of 5 mm.; a low, narrow, obscure ridge closely parallels the outer margin of the hinge; these features are best seen on right valves of *Diploschiza cretacea minor*, attached to shell fragments, from Texas (see Pl. 38, fig. 14).

The inner surface of the shell is lined with fine, sharp, irregularly spaced, radiating ridges of varying strength on different individuals; the interspaces are much wider than the ridges, but may vary markedly on the same individual and on different individuals; there is a tendency to a paired arrangement of these ribs on some shells especially on left valves; new ribs may be intercolated between the others at different distances from the beak. The ridges extend out to, or a little beyond, a line well back from the margin, where the inner surfaces of the two valves meet. This line of junction

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EXPLANATION OF PLATE 38

FIGS. 1, 1*a*, 2—*Diploschiza cretacea* Conrad, reproductions of Conrad's original figures in Am. Jour. Conch., vol. 2, pl. 9, figs. 2, 3, 1886. (p. 277)

3–4, 9—*Diploschiza cretacea* Conrad, neotypes (U. S. Nat. Mus., Cat. No. 75105). 3 and 3*a*, A right valve similar to the right valve figured by Conrad; 4, 4*a*, interior of a right valve; 9, exterior of a right valve showing large scar of attachment. (p. 277)

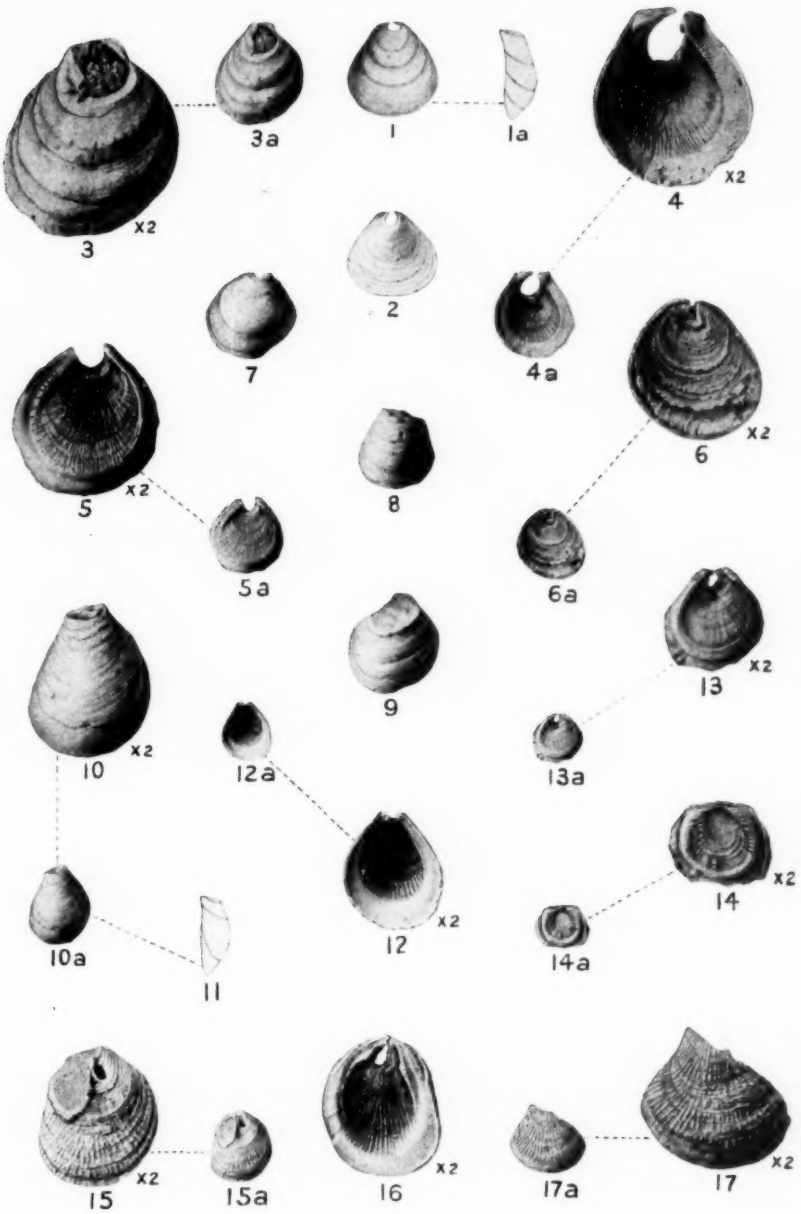
5–8—*Diploschiza cretacea* Conrad, neotypes (U. S. Nat. Mus., Cat. No. 75106). 5, 5*a*, Interior of left valve; 6, 6*a*, exterior of a left valve; 7, 8, exteriors of right valves showing scars of attachment. (p. 277)

10, 10*a*, 11—*Diploschiza cretacea minor*, n. var., holotype (U. S. Nat. Mus., Cat. No. 75107). 10, 10*a*, Exterior of right valve of holotype; 11, rear end view of holotype, showing convexity. (p. 278)

12–14—*Diploschiza cretacea minor*, n. var., paratypes (U. S. Nat. Mus., Cat. No. 75108). 12, 12*a*, Interior of a right valve; 13, 13*a*, interior of a left valve; 14, 14*a*, interior of a left valve. (p. 278)

15, 15*a*, 16—*Diploschiza cretacea striata* n. var., holotype (U. S. Nat. Mus., Cat. No. 75109). 15, 15*a*, Exterior of holotype, a right valve; 16, interior of holotype. (p. 279)

17, 17*a*—*Diploschiza cretacea striata* n. var., exterior of one of the paratypes, an incomplete right valve (U. S. Nat. Mus., Cat. No. 75110). (p. 279)



Stephenson, Upper Cretaceous Pelecypoda

appears as a slightly raised concentric ridge on some specimens; traced to the right and to the left around toward the beak this line or ridge becomes in each direction, on well preserved specimens, a thin, raised, finely crenulated ridge, the two ends meeting at a right or obtuse angle at the center of the hinge. On account of the weakness of the shell in the umbonal region, this part of most individuals is broken away or imperfectly preserved, but an occasional right valve, supported by the fragment of extraneous shell to which it is attached, exhibits a faint suggestion of a pair of small, short, crural ridges diverging inwardly.

No trace of muscle scars can be seen on the inner surfaces of any of the available material. This may be due to the failure of preservation of a thin inner shell layer.

The internal features of this shell suggest a close relationship to the dimyarian genus *Dimya*, but the failure of preservation of the muscle scars prevents a confirmation of this relationship. Tentatively the genus may be classed with the Dimyidae until more is known about it. In form the genus is somewhat like the monomyarian genus *Plicatula*, but the diminutive size and the obscurity of the crural ridges seem to exclude it from that group.

In the Upper Cretaceous of England[7] the species *Plicatula sigillina* Woodward, whose reported stratigraphic range is from the Cambridge greensand (Cenomanian) to the *Belemnitella mucronata* zone (Maestrichtian), should probably be referred to *Diploschiza*. The types came from the *B. mucronata* zone. Other English species which suggest *Diploschiza* in external appearance are *Plicatula minuta* Seeley[8] from the Cambridge greensand (Cenomanian), and *Plicatula barroisi* Peron,[9] recorded as ranging from the *Rhynchonella cuvieri* zone (lower Turonian) to the *Belemnitella mucronata* zone (Maestrichtian).

[7] Woods, Henry, A monograph of the Cretaceous Lamellibranchia of England: *Paleontographical Soc.*, vol. 1, pt. 3, p. 143, pl. 26, figs. 19–22, 1901.

[8] Woods, Henry, *op. cit.*, p. 138, pl. 15, figs. 22–25.

DIPLOSCHIZA CRETACEA Conrad

Plate 38, figures 1–9

Diploschiza cretacea CONRAD *1866*, Am. Jour. Conch., vol. 2, pp. 77, 105, pl. 9, figs. 2, 3. —TRYON, *1884*, Structural and systematic conchology, Mollusca, vol. 3, p. 295, pl. 133, figs. 27, 28.—WHITFIELD, *1885*, U. S. Geol. Survey, Mon., vol. 9, p. 43, pl. 4, figs. 6–8 (not figs. 4, 5). New Jersey Geol. Survey, Paleontology, vol. 1, p. 43, pl. 4, figs. 6–8 (not figs. 4, 5), 1886.

The following is Conrad's description of the species:

Short-ovate; large valve ventricose, with one to three distant concentric undulations; umbo truncated; smaller valve deeply concave; cardinal notch carinated on both sides. Length one-half inch.

The internal features of the shell have already been described under the generic heading. The outline is broadly ovate to subcircular. The surface is smooth except for fine incremental lines, widely spaced growth undulations, and very obscure traces of radiating striae. The individuals vary greatly in convexity, some of them attaining as much as 5 mm. The maximum length of shell measured is 13 mm. or approximately half an inch.

The shells of both valves are very thin and flimsy in the umbonal region, but become quite stout and substantial midway to the margin. The scar of attachment on the right valve varies from very small to a maximum dimension of at least 8 mm.

The species differs from the Texas variety *minor*, described below, in its consistently greater size and its greater tendency to assume subcircularity of outline. It differs from the Massillon, Alabama, variety, *striata*, in the practical absence of radiating striae.

[9] Woods, Henry, *op. cit.*, p. 141, pl. 16. figs. 12–18.

Types.—Conrad's original type is believed to be lost. Seven selected neotypes from Demopolis, Alabama, U. S. Nat. Mus., Cat. Nos. 75105 and 75106.

Occurrence and distribution.—The species occurs in a fine, light-gray, massive facies of the Selma chalk. So far as known the species is restricted to a zone 60 or 70 feet thick, which lies above the middle of the Selma chalk and probably something like 200 feet below the top of the zone of *Exogyra ponderosa*. In terms of the European section the zone is of Campanian age. The species has been found at the following localities in Alabama: Bluff on Tombigbee River at Demopolis, Marengo County (U. S. Geol. Survey Colls. 6435*a*, upper end of bluff below Boltons Ferry, and 6435*b*, below boat landing, localities of neotypes; also Coll. 6931); bluff on Warrior River, near plant of Portland Cement Company, a mile east of Demopolis (U. S. Geol. Survey Coll. 6434); Jones Bluff on Tombigbee River at Epes, Sumter County (U. S. Geol. Survey Coll. 6806).

DIPLOSCHIZA CRETACEA MINOR Stephenson, n. var.

Plate 38, figures 10–14

The shells here referred to the new variety *Diploschiza cretacea minor*, are identical in surface and internal features with the typical species, but are consistently smaller and, although variable in outline, they show a definite tendency to greater elongation in the direction of the height, and a more constricted umbonal region. Because of these differences and the wide geographic separation of the Texas shells from the Alabama ones they seem worthy of varietal separation. The holotype, a specimen with the two valves closely attached, measures 9 mm. in length, 10.5 mm. in height, and 4 mm. in thickness.

Types.—Holotype, U. S. Nat. Mus., Cat. No. 75107; paratypes, Cat. No. 75108.

Occurrence and distribution.—The variety occurs in the Pecan Gap chalk member of the Taylor marl of central Texas, where in places it is present in great numbers. It has been collected at the following localities: Small branch at the crossing of the Otto road, just west of the International and Great Northern Railroad, about 2 miles (air line) south-southeast of Mart, McLennan County (U. S. Geol. Survey, Coll. 12913); west-facing slope of a creek valley, about 200 yards south of the Branson Brick Company's plant, 0.9 mile south by west of the court house at Marlin, Falls County (U. S. Geol. Survey, Coll. 12915, type locality); Marlin to Cedar Springs road, 5.3 miles south by east of the bridge over Deer Creek, about 5 miles east of Lott, Falls County (U. S. Geol. Survey, Coll. 12916); same road as the preceding, 5.8 miles south by east of the bridge over Deer Creek (U. S. Geol. Survey, Coll. 12917); branch of Hendricks Creek, 1.1 mile southwest of Rogers, Bell County, collected by the writer and Mr. M. B. Arick, in March, 1929 (U. S. Geol. Survey, Coll. 14611).

In addition to the localities just enumerated the variety was collected in 1933 by Mr. L. F. McCollum of the Humble Oil and Refining Company and the writer, from a zone of chalks and chalky marls representing the extension of the Pecan Gap chalk southward as far as Travis County, at the localities enumerated below. The Pecan Gap age of this zone had previously been determined on the basis of foraminifera collected by Mr. McCollum and identified by Miss Alva C. Ellisor.

Wash in field south of public road, 2.5 miles east-southeast of Bartlett, Williamson County (U. S. Geol. Survey, Coll. 16416); ditch on the old Taylor-Austin road, 2.3 miles southwest of Taylor, Williamson County (U. S. Geol. Survey, Coll. 16417); bare spot at foot of west-facing slope, east of the old Taylor-Austin road, 2.5 miles southwest of Taylor, Williamson County (U. S. Geol. Survey, Coll. 16420); bluff on Brushy Creek, right side, 0.75 mile above Rices

Crossing, Williamson County (U. S. Geol. Survey, Coll. 16422); Brushy Creek, right bank, 1.75 miles above Rices Crossing, Williamson County (U. S. Geol. Survey, Coll. 16421); Austin-Manor road, deep cut in west-facing slope of Big Walnut Creek valley, Travis County, from within 3 feet above a thin phosphatic conglomerate (U. S. Geol. Survey, Coll. 16419). A single right valve was also found by the writer in a steeply dipping bed of chalk, interbedded in the Taylor marl, in a bluff on Colorado River, right side, a mile northeast of Delvalle, Travis County (U. S. Geol. Survey, Coll. 16242).

DIPLOSCHIZA CRETACEA STRIATA Stephenson, n. var.

Plate 38, figures 15–17

In the collections of the United States Geological Survey are five right valves of *Diploschiza* from Dallas County, Alabama. These differ markedly from the typical *Diploschiza cretacea* in having the outer surface covered with numerous low, irregular, round-crested, radiating ribs. The strength of development of these ribs varies somewhat, but in all the specimens the ribs are much stronger than any of the very faint radial markings seen on the typical shells of the species. The internal radiating ribs and marginal crenulations are typical of the genus and are sharply developed.

Types.—Holotype, U. S. Nat. Mus., Cat. No. 75109. Paratypes, U. S. Nat. Mus., Cat. No. 75110.

Occurrence.—The five specimens were collected in 1883 by Mr. L. C. Johnson, from the "prairies of Massillon, Dallas County, Ala." (U. S. Geol. Survey, Coll. 265). The village of Massillon is on the Southern Railway about 3¼ miles west of Marion Junction. The station is on the outcrop of the Selma chalk, apparently stratigraphically a little below the middle of the chalk. Presumably the shells were collected from an outcrop of the Selma chalk somewhere near Massillon, but the exact locality is unknown; it may have been several miles from the village. Matrix attached to one of the paratypes is a strongly calcareous sand or sandy chalk.

SUPPLEMENTAL NOTE

After this paper was sent to press the writer was informed by Miss Alva C. Ellisor, of the Humble Oil and Refining Company, that she had found *Diploschiza* in the upper part of the Annona chalk at several localities on Lawson Creek, from the crossing of the Clarksville-Texarkana highway to within a mile north of the highway, in Red River County, Texas. In April, 1934, through the courtesy of the officials of the Humble Company, the writer had the privilege of visiting numerous outcrops of the Annona chalk and the Pecan Gap chalk in northeast Texas, in company with Miss Ellisor and Mr. John Teagle. *Diploschiza cretacea minor* was collected in Red River County at two localities in the upper part of the Annona, as follows: Lawson Creek, 2.8 miles north-northwest of Annona, 2.4 miles south by west of White Rock (U. S. Geol. Survey, Coll. 16681); and Lawson Creek, just above the crossing of the Clarksville-Texarkana highway (U. S. Geol. Survey, Coll. 16682). The occurrence of this variety in association with the large echinoid, *Echinocorys texana* (Cragin), in the upper part of the Annona as developed in Red River County, is satisfactory evidence of the approximate correspondence in age of this part of the Annona chalk with the Pecan Gap chalk of Falls County, Texas. This correlation is in substantial accord with that made by Miss Ellisor and Mr. Teagle, on evidence afforded by foraminifera, as orally stated to the writer.

Another discovery made subsequent to the time this paper was sent to press, extends the known geographic range of *Diploschiza* as far west as Medina County, Texas. In March, 1934, in company with Mr. Philip B. King, the writer examined a section in a north-facing bluff of Seco Creek, about 3.5 miles north of

D'Hanis, and found *Diploschiza cretacea minor* at the top of the Anacacho limestone in a layer of marl one foot thick near the foot of the bluff, immediately overlying a soft cream-colored limestone containing the large echinoid, *Echinocorys texana* (Cragin); this is the type locality of the latter species. The layer of marl is replete with the small shells of an undescribed species of *Terebratulina*. This occurrence of *D. cretacea minor* and *E. texana* in immediately contiguous beds, satisfactorily establishes the age equivalence of the upper part of the Anacacho limestome with the Pecan Gap chalk of central Texas and with the upper part of the Annona chalk of Red River County, Texas.

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THE CEPHALOPODS OF THE PHOSPHORIA FORMATION OF NORTHWESTERN UNITED STATES

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ABSTRACT

The Phosphoria is a marine formation that occurs in Idaho and Wyoming and adjacent areas. It is abundantly fossiliferous, but there is little unanimity of opinion as to its age. Cephalopods are confined to the middle and upper portions of the formation; they indicate that these parts of the Phosphoria are Middle Permian in age and are probably the correlative of the Word formation of Texas. Representatives of the nautiloid genera *Coelogasteroceras*, *Stearoceras*, and *Orthoceras* s. l., and the ammonoid genera *Vidrioceras*, *Stacheoceras* s. s., *Gastrioceras* s. l., and *Goniatites* s. l. are described and most of them are illustrated.

The Phosphoria is a marine formation that occurs in eastern Idaho and western Wyoming and adjacent parts of Montana, Utah, and Colorado; also the Forelle limestone and the underlying Satanka shale of southeastern Wyoming are correlatives of the Phosphoria, and strata which apparently represent extensions of it outcrop to the south in Nevada and to the north in Alberta and British Columbia. The distribution and general nature of the formation are well known from the extensive investigations of the United States Geological Survey of its contained phosphate beds; all of the available information has recently been summarized by C. C. Branson[1] who states: "In general, the Phosphoria may be said to vary from east to west from a basal shale series containing thick beds of phosphate rock, and an overlying cherty limestone, to a basal chert and limestone series with progressively poorer and thinner phosphate beds overlain by cherty shales and a massive bed of limestone. The first type is found in Colorado, Utah, Idaho, Montana, and the Sublette and Salt River ranges of Wyoming. The second type is typically developed in the Wind River and Owl Creek mountains of Wyoming." In the Wind River and Owl Creek mountains Branson was able to divide the formation into five distinct members each of which carries a characteristic fauna, but in southeastern Idaho Mansfield[2] recognized only two members. At the type locality, Phosphoria Gulch near Meade Peak, Idaho, the Phosphoria is about 415 feet thick, but over most of its area of outcrop it is much thinner.

[1] Branson, C. C., Paleontology and stratigraphy of the Phosphoria formation: *Missouri Univ. Studies*, vol. 5, no. 2, pp. 5–14, 1930.

[2] Mansfield, G. R., Geography, geology, and mineral resources of part of southeastern Idaho: *U. S. Geol. Survey, Prof. Paper* 152, pp. 75–81, 1927.

The Phosphoria is abundantly fossiliferous and its fauna has been described in part by Girty,[3] E. B. Branson,[4] C. C. Branson,[5] and others, but there is little unanimity of opinion as to its age. In 1910, Girty, after a detailed study of rather extensive collections of fossils from the lower half of the formation near the junction of Idaho, Utah, and Wyoming, concluded that the fauna should be regarded tentatively as Upper Pennsylvanian (Gschelian) in age, but he subsequently[6] referred it to the Permian. In 1916 E. B. Branson published a study of the fauna of one of the lower members of the Phosphoria in the Wind River Mountains of Wyoming and concluded that the lower part of the formation is Pennsylvanian in age and its fauna is entirely distinct from that of the upper part. In 1930, C. C. Branson, after a detailed study of all of the faunas known from the Phosphoria, sustained the conclusions of E. B. Branson and stated that he believed that the lower part of the formation is Pennsylvanian in age whereas the upper part is Permian and that there "is a gradation without a break from Pennsylvanian to Permian." In manuscript written but not published before the appearance of C. C. Branson's report, R. E. King[7] expressed the opinion that the Phosphoria is the approximate time equivalent of the Word formation of Texas and is, therefore, Middle Permian in age. Finally, J. S. Williams[8] has recently placed the Phosphoria as the time equivalent of all of the Lower and Middle Permian, but he indicated that he was uncertain as to just how much of the Permian (and possibly also the Pennsylvanian) period the formation represented.

Girty described a few ammonoids from the Phosphoria, but he was able to ascertain definitely the generic affinities of only one of them, *Gastrioceras simulator*, and the genus in which it belongs is unfortunately not very diagnostic. Nevertheless, the specimens he described indicated that detailed collecting in westernmost Wyoming might yield a considerable variety of ammonoids, and this fact, together with the difference of opinion among the students of the fauna as to its age, stimulated us to work on the problem for we have been studying Paleozoic ammonoids for some time and have become convinced of their value for detailed correlation of Late Paleozoic strata. We accordingly applied to the Graduate Research Funds of the State University of Iowa for partial expenses and we wish to take this opportunity

[3] Girty, G. H., The fauna of the phosphate beds of the Park City formation in Idaho, Wyoming, and Utah: *U. S. Geol. Survey, Bull.* 436, pp. 1–65, pls. 1–7, 1910.

[4] Branson, E. B., The lower Embar of Wyoming and its fauna: *Jour. Geology*, vol. 24, pp. 639–664, pls. 1–6, 1916.

[5] Branson, C. C., *op. cit.*, pp. 14–61, pls. 1–16.

[6] Girty, G. H., *U. S. Geol. Survey, Bull.* 452, pp. 13–14, 1911; *U. S. Geol. Survey, Prof. Paper* 111, p. 642, 1920; and *U. S. Geol. Survey, Prof. Paper* 152, pp. 78–81, 1927.

[7] King, R. E., The geology of the Glass Mountains, Texas, Part II, Faunal summary and correlation of the Permian formations with description of Brachiopoda: *Texas Univ., Bull.* 3042, pp. 30–33, 1930.

[8] Williams, J. S., *Sixteenth International Geol. Congress, Guidebook* 29, pl. 5, 1933.

to express our sincere appreciation for the liberal financial assistance that we received. Acknowledgment is also due to Dr. C. C. Branson for information as to the precise location of outcrops and to Dr. G. H. Girty, Dr. J. S. Williams, Prof. E. B. Branson, and Mr. H. D. Thomas for the loan of specimens—in order to make our study as nearly complete as possible we included all of the cephalopods known from the Phosphoria formation.

Although the specimens described below came from various localities in Wyoming, we collected only in the Sublette Range of western Wyoming very near the Idaho-Wyoming boundary. There the Phosphoria is exposed near the crest of a north-south trending anticline, the Sublette anticline, and the formation is divisible into two members, a phosphatic shale member below and the Rex chert member above. A detailed section of the strata exposed in this locality has been made by F. B. Weeks and W. F. Ferrier and published by Girty[9] and the outcrops were better when this section was made than they are now. Since this section is readily available to most paleontologists there is no need to republish it here, but it will probably be well to mention that all of the ammonoids known from the Phosphoria came from about the same horizon and all came from about 35 feet above the lowest exposed part of the Phosphoria formation and almost 150 feet above the highest exposed part of the underlying Pennsylvanian Wells formation, that is, they came from about 60 feet below the base of the Rex chert. Girty has described most of the fossils other than ammonoids that occur in the Phosphoria in this vicinity, and, as has been stated above, they indicate that the containing strata are either Late Pennsylvanian or Permian in age but nothing further. We will limit our discussion to the cephalopods.

The collections we are studying contain representatives of three genera of ammonoids (*Vidrioceras*, *Stacheoceras* s. s., and *Gastrioceras* s. l.) and three genera of nautiloids (*Orthoceras* s. l., *Stearoceras*, and *Coelogasteroceras*). All of the ammonoids came from the same general locality and the same horizon, that is, all came from the so-called "goniatite beds" of the phosphatic shale member of the Phosphoria formation in the Sublette Range of westernmost Wyoming.

The genus *Vidrioceras* is known to range from Upper Pennsylvanian to Middle Permian, but the single representative of it that occurs in the Phosphoria is closely related to only *V. pygmeaum* (Gemmellaro) of the Middle Permian Sosio beds of Sicily, which are the approximate time equivalent of the Word formation of western Texas. Furthermore, the Phosphoria form is so strikingly similar to the Sicilian species that the two must be regarded as being very closely related and they certainly are not greatly different in age.

[9] Girty, G. H., The fauna of the phosphate beds of the Park City formation in Idaho, Wyoming, and Utah: *U. S. Geol. Survey, Bull.* 436, pp. 17–19, 1910.

The genus *Stacheoceras* s. s. is known to range from the lower part of the Lower Permian to the upper part of the Upper Permian but it is abundant in only the Middle Permian, and in North America it has been found previously in only the Wichita and Word formations of Texas. It is represented in the Phosphoria by two distinct species one of which is very closely related to "*Popanoceras* [*Stacheoceras*] *timorense* form. γ" Haniel of the Middle Permian Bitauni beds of Timor whereas the other is equally close to "*Popanoceras* [*Stacheoceras*] *timorense* form. δ" Haniel of the same horizon and locality. The Bitauni beds come just under the "zone of *Waagenoceras*" (Word equivalent) in Timor and they are therefore believed to be the approximate correlative of the Leonard formation of western Texas which also comes just under the "zone of *Waagenoceras*."

The genus *Gastrioceras* s. l. has a long range in the Late Paleozoic, but all four of the Phosphoria representatives of it belong in what Böse termed the "*Group of Gastrioceras zitteli Gemm.*," which is abundant and widespread in only the Middle Permian but which occurs also in the upper part of the Lower Permian; in North America this group has been known heretofore to be represented by only *G. roadense* Böse of the Word formation of western Texas, but we have identified representatives of it from beds in northern Mexico that are equivalent in age to the Word.

It seems obvious from the facts presented in the three preceding paragraphs that the so-called "goniatite beds" of the phosphatic shale member of the Phosphoria are Middle Permian in age. They are most probably the correlative of part of the Word formation of western Texas but they may be as old as the Leonard formation which immediately underlies the Word—all of the Phosphoria ammonoids but the two species of *Stacheoceras* s. s. seem to indicate a correlation with the Word and its equivalents, but the two representatives of *Stacheoceras* are more closely related to forms that occur in beds which are believed to be the approximate time equivalent of the Leonard. Furthermore, the occurrence in the Cache Creek series of southern British Columbia of a *Propinacoceras*[10] that is strikingly similar to *P. beyrichi* Gemmellaro of the Sosio beds (Word equivalent) of Sicily seems to indicate that during Word time the Cordilleran geosyncline was occupied by a sea that extended from western Texas north at least to British Columbia, and that therefore beds of Word age might be expected in the area where the Phosphoria occurs.

We found a single nautiloid in the "goniatite beds" of the Sublette Range, but it represents only a small portion of the conch of an orthoceraconic form and as it does not retain its siphuncle its generic affinities cannot be ascertained and it is of no stratigraphic significance. C. Branson described two nautiliconic nau-

[10] Miller, A. K., and Warren, P. S., A *Propinacoceras* from North America: *Am. Jour. Sci.*, 5th ser., vol. 26, pp. 295–299, 1933.

tiloids from the "Top Limestone member" of the Phosphoria in the Wind River and Owl Creek mountains of Wyoming; both of these are referable to *Stearoceras*, a genus known to be represented by only one other species, *S. gibbosum* (Hyatt) which occurs in the Bend (basal Pennsylvanian) of north-central Texas; the Phosphoria forms are not closely similar to the Bend species and are of very little stratigraphic significance. H. D. Thomas collected in a limestone tongue in the so-called "redbed Embar" (Phosphoria equivalent) of the Rattlesnake Hills of central Wyoming several representatives of a nautiloid species that we are describing below as *Coelogasteroceras thomasi;* this form is closely similar to *C. mexicanum* (Girty) of the Yeso formation of New Mexico and it can therefore be said to indicate that the beds from which it came are Middle Permian in age.

All of the evidence as to the age of the Phosphoria, then, that can be deduced from the cephalopods is strongly in favor of Middle Permian, but it must be remembered that none of these cephalopods came from the lower portions of the formation. In a paper which has been almost invariably overlooked by students of the Phosphoria, E. B. Branson[11] described from one of the lower members of that formation in the Wind River Mountains, a fauna that is composed largely of cochliodont shark teeth. Cochliodont sharks are known to range from the Mississippian to the Upper Permian[12] but the forms described by Branson find a close parallel in only those known from the Pennsylvanian of the Upper Mississippi Valley and the Muscovian (Middle Pennsylvanian) of central Russia; certain of them (particularly *Crassidonta stuckenbergi*) are so strikingly similar to forms that Stuckenberg[13] described from the Moscovian near Samara, central Russia, that the containing beds in these two widely separated localities are probably to be correlated. These facts seem to us to indicate that the fish-bearing beds of the Phosphoria are truly of Pennsylvanian age as E. B. Branson concluded. If this is correct, and if the "goniatite beds" of the Phosphoria are Middle Permian in age, as the ammonoids indicate, then it would seem to us that both of these horizons should not be included in the same formation for it is incompatible with present ideas of stratigraphy to have a single formation embrace parts of two systems (three or four series). Since at least part of the type section of the Phosphoria is definitely Permian in age, it is the fish-bearing beds and not the "goniatite beds" that should be eliminated from the formation. They (the fish-bearing beds) should be re-

[11] Branson, E. B., *op. cit.*, pp. 639–664, pls. 1–6, 1916.

[12] Waagen (*Palaeontologia Indica*, 13th ser., vol. 1, pp. 73–75, 1857) has described some cochliodont shark remains from the "upper division of the Productus-limestone" of the Salt Range of India, which is now regarded as uppermost Permian.

[13] Stuckenberg, A., Die Fauna der obercarbonischen Suites des Wolgadruchbruches bei Samara: *Mém. du Comité Géol.*, Nouv. Sér., Livr. 23, pp. 110, 144, 1905.

garded as a distinct formation which is probably correlative with the lower member of the Park City formation of Utah, Colorado, and Idaho, and they may be the approximate time equivalent of part of the Casper sandstone of southeastern Wyoming. C. Branson[14] states that there is no stratigraphic break between the fish-bearing beds and the overlying Permian beds, but if our conclusions are correct a dividing line must be drawn between them anyhow, preferably by some one who is more familiar with the interrelationships of these beds than we are.

SYSTEMATIC DESCRIPTIONS

COELOGASTEROCERAS THOMASI
Miller and Cline, n. sp.
Plate 39, figures 26, 27

H. D. Thomas, of the University of Wyoming, collected eleven nautiloids from a limestone tongue in the so-called "redbed Embar" (Phosphoria equivalent) in the Rattlesnake Hills of central Wyoming. These apparently are all conspecific and whereas they clearly represent the genus *Coelogasteroceras*, they are not referable to any described species and we propose the name *C. thomasi* for them in honor of their discoverer.

Form subglobose as conch is fairly rapidly expanded orad, is depressed dorso-ventrally, and is nautiliconic. Whorls are subquadrate in cross section but are slightly concave ventrally, slightly convex laterally, and more strongly concave dorsally, and the ventro-lateral and dorso-lateral shoulders are narrowly rounded. The lateral sides of the conch converge ventrally and the maximum width of conch is attained at the umbilical shoulders. The preserved part of the holotype attains a maximum diameter of about 43 mm., and a maximum width and height of conch of about 34 mm. and 24 mm., respectively; at the adoral end of this specimen the ventral side of the conch is about 23 mm. wide, whereas at the adapical end of the outer volution it is only about 8 mm. wide and the conch is only about 9 mm. high and 15 mm. wide. The holotype is not complete adorally and some of the paratypes appear to be as much as 25 per cent larger. The dorsal impressed zone is about one-fifth as deep as the whorls are high.

The umbilicus is moderate in size and its diameter is equal to about two-sevenths that of the specimen; the umbilicus of the holotype attains a maximum diameter of about 12 mm. The umbilical shoulders are rather narrowly rounded. The umbilical walls are slightly convex and they are fairly steep.

The surface of the test is marked by very distinct growth-lines. On the umbilical walls these are straight and directly transverse but they curve steadily apicad as they cross the lateral and ventro-lateral zones of the conch and show that the aperture was marked ventrally by a broad, deep, rounded hyponomic sinus. On the umbilical shoulders and for a short distance on both sides of them the conch is lirate but even on well preserved specimens the lirae are not prominent and are easily overlooked. The camerae are short and along the venter their length is equal to about one-fifth the width of the conch. The sutures are directly transverse but they are slightly sinuous. On the mature portion of the conch each suture forms a very shallow, rounded ventral lobe, a similar ventro-lateral saddle, and a broader, deeper (but nevertheless very shallow) lateral lobe. The sutures appear to be essentially straight as they cross the umbilical walls and the impressed dorsal zone, but this needs verification.

[14] *Op. cit.*, p. 20.

The siphuncle is small and is central (or very nearly so) in position. It is composed of cylindrical segments which are not expanded appreciably within the camerae and it is therefore orthochoanitic in structure. Its diameter is equal to about one-tenth the width of the conch.

Remarks.—Representatives of the genus *Coelogasteroceras*, of which *Cyclonautilus* is a synonym, have been described from the Mississippian of Indiana and possibly Arkansas, the Lower Pennsylvanian of England and possibly Wales, and the Middle Permian (Yeso formation) of New Mexico. However, the species under consideration is closely similar to only *C. mexicanum* (Girty) of the Yeso formation and the form from the Satanka formation of southeastern Wyoming that is described below as "*Coelogasteroceras* sp.," but it is so closely similar to them that it indicates clearly that these three species are not greatly different in age. It differs from the Yeso form in that its ventro-lateral shoulders are more narrowly rounded, its conch is more nearly quadrate in cross section, and the lateral lobe of its sutures are somewhat deeper. The Satanka form is so incompletely known that adequate comparisons are not possible.

Occurrence.—All known representatives of this species came from a limestone tongue near the top of the so-called "redbed Embar," at the head of Casper Creek, Rattlesnake Hills, Natrona County, Wyoming, that is, about 50 miles west of Casper, Wyoming; this tongue is stated by H. D. Thomas, who collected the specimens, to be the correlative of the "Top Limestone member" of the Phosphoria in the Wind River Mountains of west-central Wyoming. The nautiloids occur in association with *Punctospirifer* [*Spiriferina*] *pulchra* (Meek).

Types.—State University of Iowa, 701 (holotype) and 702 (paratype); University of Wyoming (paratypes).

COELOGASTEROCERAS sp.

A single nautiloid was found by H. D. Thomas in the Satanka formation of southeastern Wyoming. This specimen is an internal mold representing the adapical portion of the living chamber of a form that appears to be closely similar to *Coelogasteroceras thomasi*, described above, and *C. mexicanum* (Girty) of the Yeso formation of New Mexico, and it is of about the same size and shape as the types of those species. Unfortunately, it is too crushed and incomplete to merit detailed description, adequate comparisons with other species are not possible, and a satisfactory illustration can not be obtained. However, this specimen appears to differ materially from *C. thomasi* only in that it is less rapidly expanded orad, the groove in the ventral side of its conch is deeper, and the lateral sides converge ventrad less strongly; part, or possibly all, of these differences may be due to the lateral crushing which this specimen has obviously undergone.

Occurrence.—Basal fossiliferous limestone of the Satanka formation at Gypsum Butte, near Red Mountain, southern Albany County, Wyoming. H. D. Thomas[15] has called our attention to the fact that "this is the bed which Darton and Lee confused with the Forelle, and which carries the fauna given in paragraphs 4 and 5, page 21, U. S. Geol. Survey, Bull. 364." Thomas also stated that he has found numerous species not contained in this list and that among them is *Allorisma capax* Newberry, which also occurs in the Yeso formation of New Mexico.

Repository.—State University of Iowa, 714.

Genus STEAROCERAS Hyatt

This genus was established by Hyatt[16] in 1893 and one species, *Endolobus gib-*

[15] Personal communication, dated September 25, 1933.

[16] Hyatt, Alpheus, Carboniferous cephalopods; second paper: *Texas Geol. Survey, Ann. Rept.* 4, p. 422, 1893.

bosus Hyatt of the Bend group of San Saba County, Texas, was referred to it. In the description of this species, which immediately follows the generic diagnosis, Hyatt states that the specimen studied and illustrated at the time he founded the genus, and not the holotype of *Endolobus gibbosus*, is the genotype. However, both this specimen and the holotype came from the same general locality and probably the same horizon and there seems to be no good reason to doubt that they are conspecific, though positive identification can not be made as they represent different parts of the conch.

Hyatt associated this genus with *Coloceras* and *Planetoceras* and it certainly is closely related to them. *Planetoceras*, of which the genotype is *P. retardatum* Hyatt of the Viséan (Upper Mississippian) of Belgium, differs particularly in that its umbilical shoulders are carinate and the adoral portion of its conch is evolute. The genotype of *Coloceras* is *C. hyatti* Miller, Dunbar, and Condra, which also came from the Viséan of Belgium; unfortunately the holotype of that species represents only the nepionic portion of the conch and mature representatives of the species are not known. Nevertheless, the genotypes of *Coloceras* and *Stearoceras* are similar in shape of conch and their siphuncles are probably identical in structure; neither bears prominent surface markings and if these two genera are to be differentiated it must be done on the basis of their sutures. The sutures of the genotype of *Stearoceras* form very shallow ventral, lateral, and dorsal lobes, whereas those of the genotype of *Coloceras* are straight. It is of course possible that the sutures of mature representatives of the genotype of *Coloceras* do not differ materially from those of *Stearoceras* but until this can be established it will be best to consider both as valid genera. The two nautiloids described below have sinuous sutures and they are much more closely similar to the genotype of *Stearoceras* than to the genotype of *Coloceras* and we are, therefore, referring them to the former genus.

STEAROCERAS PHOSPHORIENSE (C. Branson)

Text figure 1

Asymptoceras phosphoriense C. BRANSON, *1930*, Univ. of Missouri Studies, vol. 5, no. 2, p. 59, pl. 12, fig. 11; pl. 15, figs. 4, 5.

Coloceras phosphoriense MILLER, *1933*, Pal. Zentralblatt, Bd. 2, p. 349.—MILLER, DUNBAR, and CONDRA, *1933*, Nebraska Geol. Survey, Bull. 9, 2d. ser., p. 131.

This species was recently described and illustrated by C. Branson who based it on a single specimen which has been made available for study through the courtesy of Prof. E. B. Branson. C. Branson's illustrations are as good as can be obtained from the rather fragmentary holotype and there is no need for us to duplicate his work. However, since there appears to be considerable variation in opinion as to the generic affinities of this form, certain of its characters should be described in more detail than is ordinarily necessary.

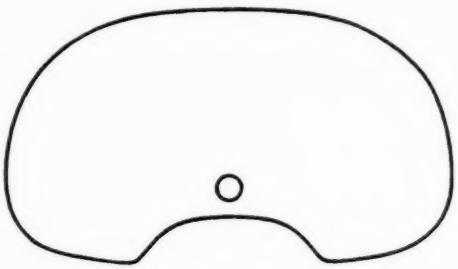


FIG. 1.—*Stearoceras phosphoriense* (C. Branson). Diagrammatic cross section of conch of holotype showing shape of adoral portion of phragmacone and size and position of siphuncle at its passage through a septum, ×1.

The subglobose conch is kidney-shaped in cross section and is strikingly similar in this respect to that of *Stearoceras gibbosum* (Hyatt), the genotype of *Stearoceras;* on the adoral portion of the holo-

type the ventral side of the conch is slightly concave but this may be due to distortion during preservation. Each suture forms a broad, very shallow, evenly rounded ventral lobe, a similar but narrower ventro-lateral saddle and lateral lobe, and a similar but still narrower dorso-lateral saddle. The internal sutures of the holotype are not visible but very shallow lobes are formed on the broad, steep umbilical walls. Faint traces of the growth-lines are discernible on the adoral portion of the holotype; they indicate that the conch is marked ventrally by a large, deep, U-shaped hyponomic sinus, much like that of *S. gibbosum*. The siphuncle is located somewhat dorsad of the center of the conch; it appears to be orthochoanitic in structure, but this needs verification.

C. Branson referred this species to *Asymptoceras*. The type of that genus is *A. cyclostomum* (Phillips) of the Mississippian of England and possibly Ireland, Belgium, and Russia; it is a tarphyceraconic, evolute form that is subcircular in cross section and has a ventral (marginal) siphuncle, and it is not at all closely related to the above-described Phosphoria form. As is explained above in the generic discussion, *Coloceras* apparently differs materially from *Stearoceras* only in that the sutures of the former are straight whereas those of the latter bear shallow ventral and lateral lobes.

The holotype of *S. phosphoriense* is so fragmentary and incomplete that adequate specific comparisons are not possible. However, it can be readily differentiated from *S. gibbosum*, the only species which has heretofore been referred to this genus, by the fact that its conch is less rapidly expanded orad and its camerae are relatively shorter.

Occurrence.—"Top Limestone member" of Phosphoria formation, Bighorn Canyon in Owl Creek Mountains, near Thermopolis, Wyoming.

Holotype.—University of Missouri, 5326.

STEAROCERAS sp.

Coloceras sp. C. BRANSON, *1930*, Univ. of Missouri Studies, vol. 5, no. 2, p. 59, pl. 15, fig. 3.

C. Branson figured and very briefly described a second nautiloid from the Phosphoria as "*Coloceras* sp." This specimen has unfortunately been misplaced. Its general physiognomy indicates clearly that it represents either *Coloceras* or *Stearoceras*, but since C. Branson states that its "sutures are slightly lobed on the sides, and distinctly lobed on the venter," we are referring it to *Stearoceras*.

Occurrence.—Representatives of this form are stated by C. Branson to occur in the "Top Limestone member" of the Phosphoria formation in the Wind River and Owl Creek mountains of Wyoming.

Genus ORTHOCERAS Bruguière

"ORTHOCERAS" sp.

Our collection from the Phosphoria contains a single fragment of a long straight nautiloid that is too incomplete to figure but is deserving of mention since it apparently is the only orthoceraconic cephalopod known from the formation. This specimen is an internal mold of part of three chambers of the phragmacone. It apparently was about 15 mm. in diameter and was expanded orad very gradually. The internal mold at least is smooth and is entirely devoid of markings other than the sutures, which apparently are straight and, being directly transverse to the long axis of the conch, are simple circles. The camerae are long and their length is equal to about half their diameter.

The internal structures of this specimen are not preserved and hence its generic affinities can not be ascertained. There is no good reason to believe that it is at all closely related to *Orthoceratites regularis* Schlotheim, which probably is to be regarded as the genotype of *Orthoceras*, and we are using that generic name in its old, broad sense, which is no longer justifiable—to call attention to this fact

we are inclosing the generic name in quotation marks. It may be that this form represents *Trematoceras* Eichwald (not Whitfield nor Hyatt) or *Michelinoceras* Foerste, but until the nature of its siphuncle is ascertained it will not be possible to refer it definitely to any genus.

Occurrence.—"Goniatite beds" of phosphatic shale member of Phosphoria formation, south side of Raymond Canyon, Sublette Range, westernmost Wyoming.

Repository.—State University of Iowa, 703.

Genus VIDRIOCERAS Böse

VIDRIOCERAS GIRTYI Miller and Cline, n. sp.

Plate 39, figures 15–17

Popanoceras ? sp. GIRTY, *1910*, U. S. Geol. Survey, Bull. 436, p. 55, pl. 7, figs. 15, 15*a*.

This species is being based on a single specimen which is the same one that was studied and described by Girty. It was kindly loaned to us for study and we take pleasure in naming it in honor of Doctor Girty.

Form subdiscoidal; conch ammoniticonic in its mode of growth and expanded orad fairly rapidly; whorls rounded ventrally but rather strongly flattened laterally. The holotype, an essentially complete internal mold of a mature individual, attains a maximum diameter, measured from the adoral end of the venter across the umbilicus to the opposite side of the specimen, of about 15¼ mm.; the diameter at right angles to this and across the umbilicus measures about 13¾ mm. With the exception of the last volution, the conch is wider than high, but the adoral portion of the conch is expanded more rapidly dorso-ventrally than laterally and the conch therefore becomes higher than wide. At the adoral end of the holotype, the conch is about 8 mm. high and 7 mm. wide (estimated); at the adoral end of the penultimate volution the conch is only about 4½ mm. high and 5½ mm. wide.

The umbilicus is very small and is not very deep, so that none of the inner volutions of the conch is exposed. The umbilical shoulders are rounded and are not very distinct.

Near the adoral end of the specimen the internal mold is marked by a deep rounded constriction which is transverse to the long axis of the conch but is slightly sinuous—it curves orad slightly as it crosses the lateral sides of the conch. This constriction presumably represents a ridge or internal thickening on the inside of the conch and, since orad of it the conch was flared, it most probably was located immediately adjacent to the aperture. If this is correct, then the living chamber was almost exactly one volution in length for the adoral suture of the holotype is located on the extreme adapical end of the outer volution. The apertural margins are not retained on the holotype, but the aperture was apparently large and flaring.

The internal sutures of this specimen are not visible, but each external suture consists of a total of seven primary lobes and eight primary saddles; there is in addition a small subangular lobe on each umbilical shoulder. All of the large, primary lobes are digitate but all of the primary saddles are undivided. The ventral lobe is short and broad and it is divided medianly by a relatively broad secondary saddle, which in turn is divided by a small rounded tertiary lobe. Each of the prongs or major subdivisions of the ventral lobe is distinctly curved longitudinally. The external saddle is rounded and undivided but it is strongly contracted apicad. The first lateral lobe is about as long as the ventral lobe but it is not as wide and it is trifid; its central subdivision is longer and narrower than its lateral ones. The first lateral saddle is similar in shape to the external saddle but it is smaller. The second lateral lobe is similar in shape to the first lateral lobe but it is smaller. The second lateral saddle is similar in shape to the first lateral saddle but it is smaller. The third lateral lobe is similar in shape to the

second lateral lobe but it is shorter and much broader. The third lateral saddle is short, broad, and asymmetrically U-shaped. It is followed by a small subangular lobe that is located on the rounded umbilical shoulder. The adoral sutures of the holotype are not as far apart as are the preceding ones, which indicates that this specimen represents a mature individual.

Remarks.—The genus *Vidrioceras*, of which *V. uddeni* Böse is the genotype, is represented in the Gaptank formation of western Texas by *V. uddeni* Böse and *V. irregulare* Böse, in the Sosio beds of Sicily by "*Stacheoceras*" *pygmaeum* Gemmellaro, in the Permian limestone of Crimea by the form that Toumansky[17] referred to "*S.*" *pygmaeum*, in the Permian of Darwas in Bokhara by "*Popanoceras*" *romanowskyi* Karpinsky, and in the Somohole and Bitauni beds of Timor by "*Popanoceras*" *timorense* Haniel, "*Marathonites*" *gracilis* Smith, and *Vidrioceras wanneri* Schindewolf; the genus can, therefore, be said to range from the Upper Pennsylvanian to the Middle Permian. *V. girtyi* is much more closely similar and therefore presumably much more closely related to *V. pygmaeum* than to any other described species; the size and shape of its conch, the adapertural constriction, and even most of the details of its sutures are strikingly similar to those of that species, and the two can be said to differ materially only in that the third lateral lobe of the sutures of the American form is much broader than the preceding one whereas in the Sicilian species the reverse is the case (see Pl. 39, fig. 17 and 18).

J. P. Smith[18] has stated that *Vidrioceras* is a synonym of *Shumardites*, but as pointed out by Schindewolf[19] this is not the case, for the so-called first, second, and third lateral lobes of *Shumardites* are in reality all subdivisions of the first lateral lobe and are not independent primary lobes, and in addition the internal sutures[20] of the two genera are markedly different. We are of the opinion that these two genera do not belong in even the same family and we would place *Shumardites* in the Goniatitidae and *Vidrioceras* in the Popanoceratidae.

Occurrence.—The holotype and only known representative of this species came from the so-called "goniatite beds" of the phosphatic shale member of the Phosphoria formation, on the south side of Raymond Canyon, Sublette Range, westernmost Wyoming.

Holotype.—U. S. Geological Survey, 1726.

Genus STACHEOCERAS Gemmellaro

Schindewolf[21] has recently discussed the generic subdivision of the Popanoceratidae and has proposed to leave in the genus *Stacheoceras* s. s. forms with five to eight pairs of primary lateral lobes in their external sutures—those with four pairs of primary lateral lobes he assigned to *Marathonites*, and he coined a new generic term, *Neostacheoceras*, for those with nine to eleven pairs of primary lateral lobes. The genotype of *Stacheoceras* is *Arcestes antiquus* Waagen of the Upper Productus limestone of the Salt Range of India, and each of its external sutures possess eight pairs of primary lateral lobes. It seems likely that eventually separate generic terms will have to be proposed for the forms that possess five pairs of primary lateral lobes in their

[17] Toumansky, O., The Permo-Carboniferous beds of the Crimea; part 1, Cephalopoda, Ammonoidea, pp. 49, 95, 1931. See also *Centralblatt f. Min., Geol. u. Pal.*, Abt. B, Jahrg. 1931, p. 89, 1931.

[18] Smith, J. P., Permian ammonoids of Timor: *Jaarb. Mijnw. Nederlandsch-Indië, Jaarg.* 55, 1926, Verh. I, pp. 44–45, 1927.

[19] Schindewolf, O. H., Über den Ammoniten-Sipho: *Sitzungsber. Preuss. geol. Landesanst.*, Heft 6, p. 201, 1931.

[20] The internal sutures of *Shumardites* have recently been figured by us: *Jour. Paleontology*, vol. 8, no. 2, pl. 28, opp. p. 174, 1934.

[21] Schindewolf, O. H., Über den Ammoniten-Sipho: *Sitzungsber. Preuss. geol. Landesanst.*, Heft 6, p. 201, 1931.

external sutures, those that possess six pairs, and those that possess seven pairs, but such generic refinement is hardly necessary at present and we propose to follow Schindewolf "um die Zersplitterung nicht zu weit zu treiben." *Stacheoceras* as thus conceived is abundant in the Sosio beds of Sicily, in the Permian limestone of the Marta River region in Crimea, and in the Bitauni beds of Timor, and it occurs also in the Wichita and Word formations of Texas and in the Upper Productus limestone of the Salt Range of India; it can therefore be said to range from the lower part of the Lower Permian to the upper part of the Upper Permian, but it is abundant in only the Middle Permian.

We have found two representatives of this genus in the Phosphoria. They are closely similar only to forms known from the Middle Permian Bitauni beds of Timor. In so far as we are able to tell from the published information in regard to the Timor species our forms differ from them materially only in the details of the digitation of the lobes and this is not very significant for the degree of digitation in this genus increases progressively during the ontogenetic development. The fact that both of the Phosphoria representatives of this genus find close parallels in the Bitauni beds indicates that these two horizons are not greatly different in age.

Stacheoceras s. s. has been found before

EXPLANATION OF PLATE 39

With the exception of figures 18, 22, and 25–27, all of the specimens illustrated on this plate came from the so-called "goniatite beds" of the phosphatic shale member of the Phosphoria formation on the western side of the Sublette Range, westernmost Wyoming, near Raymond, Idaho.

FIGS. 1–4—*Gastrioceras brevicostatum* Miller and Cline, n. sp. Lateral and ventral views (×2) and diagrammatic representation of a suture (×5) of holotype. (p. 298)

5–7—*Gastrioceras stenolobatum* Miller and Cline, n. sp. Lateral and ventral views (×1) and diagrammatic representation of a suture (×5) of holotype. Figure 5 is an unretouched photograph. (p. 299)

8–10—*Gastrioceras williamsi* Miller and Cline, n. sp. Lateral and ventral views (×1) of holotype and diagrammatic representation of a suture (×5) based largely on the holotype but in part on the paratype. Figure 8 is copied from Girty. (p. 301)

11–14—*Gastrioceras simulator* Girty. Lateral and ventral (in outline) views (×1) and diagrammatic representation of a suture (×5) of holotype, and ventral view (unretouched photograph) of a paratype. Figure 11 is copied from Girty. Figure 12 is in part restored. Figure 14 represents the same specimen that Girty figured in outline. (p. 297)

15–17—*Vidrioceras girtyi* Miller and Cline, n. sp. Lateral and ventral (in outline) views (×1) and diagrammatic representation of a suture (×4) of holotype. Figures 15 and 16 are copied from Girty. In figure 17 the ventral lobe of the suture is in part restored and it may be too narrow. (p. 290)

18—*Vidrioceras pygmaeum* (Gemmellaro) of the Sosio beds (*Calcare compatto*) of Sicily. Enlarged diagrammatic representation of a suture introduced here for comparison with the sutures of *V. girtyi*. Adapted from Gemmellaro. (p. 291)

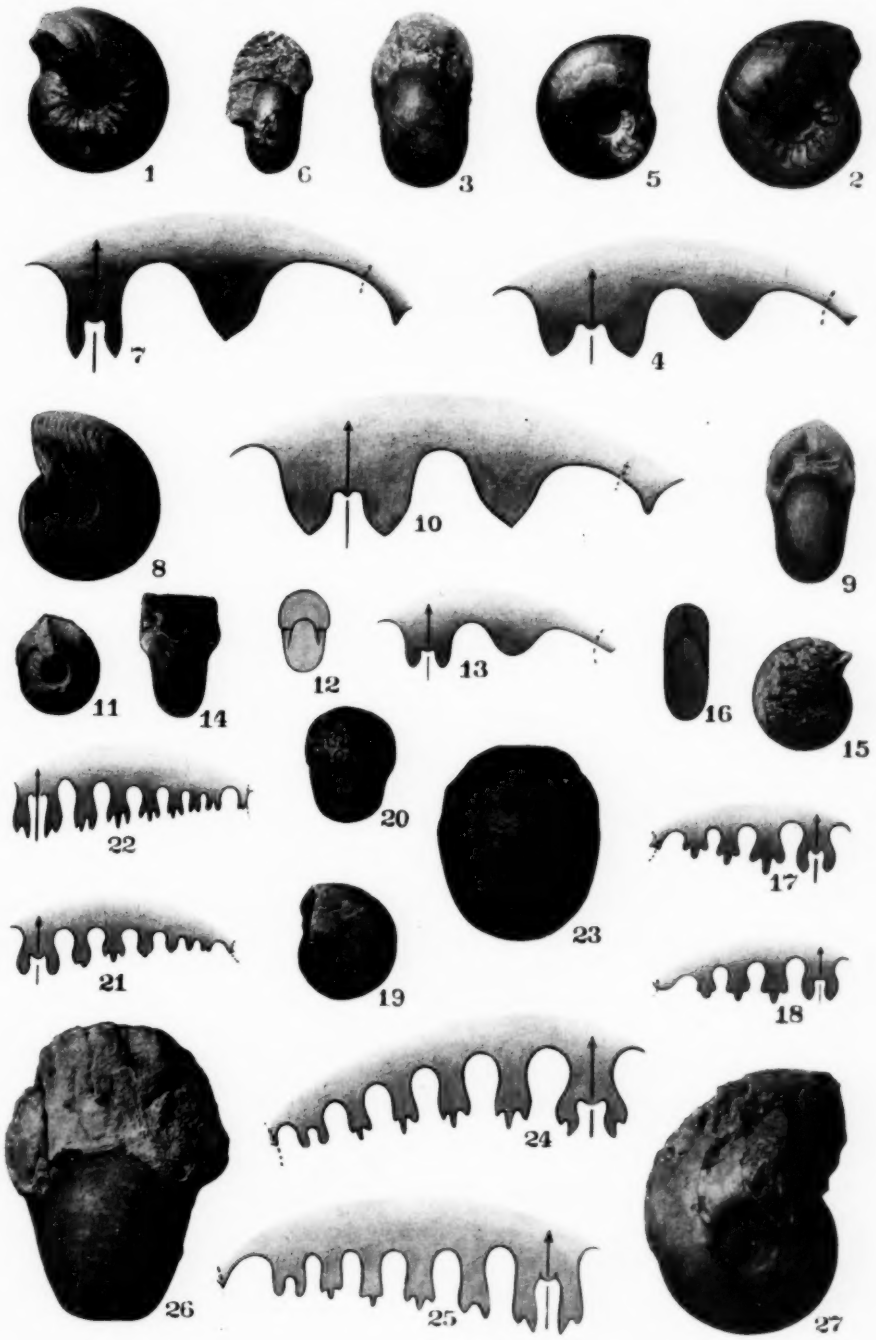
19–21—*Stacheoceras sexlobatum* Miller and Cline, n. sp. Lateral and ventral views (×2) and diagrammatic representation of a suture (×4) of holotype. (p. 294)

22—"*Popanoceras* [*Stacheoceras*] *timorense* form. δ" Haniel of the Bitauni beds of Timor. Diagrammatic representation of a suture (×¾) introduced here for comparison with the sutures of *S. sexlobatum*. Adapted from Haniel. (p. 295)

23–24—*Stacheoceras bransonorum* Miller and Cline, n. sp. Ventral view (×2) and diagrammatic representation of a suture (×4) of holotype. (p. 293)

25—"*Popanoceras* [*Stacheoceras*] *timorense* form. γ" Haniel of the Bitauni beds of Timor. Diagrammatic representation of a suture (×1¼) introduced here for comparison with the sutures of *S. bransonorum*. Adapted from Haniel. (p. 294)

26–27—*Coelogasteroceras thomasi* Miller and Cline, n. sp. Ventral and lateral views (×1) of the holotype, from a limestone tongue near the top of the so-called "red-bed Embar" (Phosphoria equivalent), Rattlesnake Hills, Wyoming. (p. 286)



Miller and Cline, Permian cephalopods

SMU DE 410

in North America only in the Word (Middle Permian) and Wichita (Lower Permian) formations of Texas. The single species known from the Wichita is not at all closely related to our forms. Both of the species that have been described from the Word are so incompletely known that adequate comparisons are not possible.

STACHEOCERAS BRANSONORUM Miller and Cline, n. sp.

Plate 39, figures 23, 24

We found in the Phosphoria formation two specimens which represent an undescribed species of the genus *Stacheoceras* and we are naming it after Drs. E. B. and C. C. Branson in recognition of their work on the Phosphoria. The larger of the specimens is the more nearly complete and we therefore designate it as the holotype. The species can be characterized as follows:

Form subglobose as conch is ammoniticonic in its mode of growth and is rapidly expanded orad. The preserved part of the holotype, which apparently represents most of the phragmacone and consists of some three or four volutions, attains a maximum diameter, measured from the adoral end of the venter across the umbilicus to the opposite side of the specimen, of about 14 mm., and a maximum width of about 12 mm. The ventral side of the conch is broadly rounded and it rounds evenly into the lateral sides, which are only very slightly flattened. The umbilical shoulders are rather abrupt and are narrowly rounded. The umbilicus is very small and is closed; that of the holotype attains a maximum diameter of only about $1\frac{1}{2}$ mm.

The surface of the internal mold is marked by transverse constrictions which are very slightly sinuous; they curve slightly orad as they cross the lateral sides of the specimen and very slightly apicad as they cross the broad ventral side. There appears to be only two, or at the most three, of these constrictions to the volution, and they are not as prominent as they are in many comparable forms.

Each external suture consists of a total of eleven primary lobes, all of which are digitate, and twelve primary saddles, all of which are rounded and undivided; there is, in addition, a small pointed lobe on each umbilical shoulder. The ventral lobe is short and broad and is symmetrical; it is divided medianly by a short, broad secondary saddle, which in turn is divided by a low broad tertiary lobe. Each of the major prongs or subdivisions (secondary lobes) of the ventral lobe is unequally bifid as its dorsal subdivision is much smaller than its ventral. The external saddle is rounded, undivided, and moderately wide, and it is rather strongly constricted apicad; all of the other primary saddles are similar in shape but they are progressively shorter and less strongly constricted with increasing distance from the venter so that those in the vicinity of the umbilical shoulders are U-shaped. The first lateral lobe is unequally trifid; its ventral subdivision is larger than the other two, its central one is longer and narrower, and its dorsal one is smaller and shorter. The second lateral lobe is similar in shape to the first lateral lobe but its dorsal subdivision extends farther apicad than its ventral, whereas in the first lateral lobe the reverse is the case. The third lateral lobe is similar to the first lateral lobe but it of course is smaller and its dorsal subdivision is much smaller than its ventral. The fourth lateral lobe is similar to the third but it is smaller. The fifth lateral lobe, however, is markedly different from the preceding ones for it is bifid and both of its subdivisions are relatively large and the median secondary saddle in it is about half as deep as the lobe is long; the prongs or subdivisions of this lobe are narrowly rounded but the dividing saddle is more broadly rounded. The lobe on the umbilical shoulder can not be made out very clearly, but it appears to be short, asymmetrical, and pointed. The internal su-

tures are not visible on either of the known representatives of this species.

The single paratype represents only a portion of the phragmacone. It attains a maximum diameter of about 7 mm. and a maximum width of about 6 mm. Due to its small size and the nature of its preservation, the details of its sutures are difficult to discern, but in general plan its sutures are closely similar to those of the holotype and they appear to differ from them only in that the lobes are less strongly digitate; this is due not only to the small size of the specimen but also to the etching to which it has been subjected.

Remarks.—This species is closely similar to only the form from the Middle Permian Bitauni beds of Timor that Haniel[22] described as "*Popanoceras timorense* form. γ." In so far as we are able to tell from the published information in regard to that form, our species differs from it materially only in that the median saddle in the ventral lobe of its sutures is shorter and broader than is that of the Timor form and the first lateral lobe of our species is trifid whereas that of the Timor form is bifid—otherwise the sutures of the two forms are so strikingly similar that they must be regarded as being very closely related and they most probably are not greatly different in age (see Pl. 39, figs. 24 and 25).

Occurrence.—Both of the types of this species came from the so-called "goniatite beds" of the phosphatic shale member of the Phosphoria formation, on the south side of Raymond Canyon, Sublette Range, westernmost Wyoming.

Types.—State University of Iowa, 704 (holotype), 705 (paratype).

STACHEOCERAS SEXLOBATUM
Miller and Cline, n. sp.
Plate 39, figures 19–21

Conch small, subglobose, ammoniticonic, rapidly expanded orad, and depressed dorso-ventrally. Ventral and lateral sides are broadly rounded and dorsal side is somewhat impressed. Maximum diameter of holotype, an internal mold of all of phragmacone and part of living chamber, measures about 8½ mm.; diameter at right angles to this measures about 7 mm. At adoral end of preserved part of holotype, which does not represent the aperture, the conch is about 6½ mm. wide and 4½ mm. high, and it is impressed dorsally to about one-third its height. At adapical end of outer volution of holotype conch is about 4 mm. wide and 3 mm. high.

Umbilicus small; that of holotype attains a maximum diameter of only about 1½ mm. Umbilical shoulders low and rounded and therefore not very distinct.

Surface of conch smooth and there is no indication of transverse constrictions such as occur in other members of this genus though they may well have been present and failed of preservation. Internal sutures of holotype not visible, but each external suture consists of a total of thirteen primary lobes and fourteen primary saddles and there is in addition a small lobe on each umbilical seam. The ventral lobe is short and broad and it is divided by a short, broad, U-shaped median saddle which in turn is divided by a short rounded tertiary lobe; both of the major subdivisions (secondary lobes) of the ventral lobe are short and more or less tongue-shaped. All of the primary saddles of the external sutures are rounded and undivided; the saddles near the venter are rather strongly contracted adapically but the amount of contraction as well as the size of the saddles decreases progressively toward the umbilical seam and the third, fourth, and fifth lateral saddles are U-shaped; the sixth lateral saddle, however, is distinctly broader than the preceding one and unlike it is asymmetrical. The first lateral lobe is very much narrower than the ventral lobe and it is spatulate; it appears to be asymmetrically bifid but the preservation of the specimen is such that it is

[22] Haniel, C. A., Die Cephalopoden der Dyas von Timor: *Pal. von Timor*, Lieferung 3, 6, pp. 97–98, text fig. 27, 1915.

difficult to make out the finer details of the shape of the lobes. The second lateral lobe is broader but shorter than the first, and it is symmetrically trifid; its central subdivision is longer than its lateral ones, however. The third lateral lobe is shorter and narrower than the second and it is not appreciably contracted near its adoral end; it appears to be somewhat trifid but its exact nature is difficult to discern. The fourth lateral lobe is similar to the third but is smaller. The fifth lateral lobe is smaller than the fourth and it is more or less V-shaped but its apex is narrowly rounded. The sixth lateral lobe differs markedly from the preceding one and is broader than it is; it (the sixth lateral lobe) is short, broad, and nearly straight-sided and it is divided centrally by a small rounded secondary saddle that is similar in size and shape to the secondary lobes which it separates. The lobe on the umbilical seam is small and it appears to be subangular.

We have a second specimen that we are referring with question to this species—the details of its sutures can not be made out. It retains a portion of the living chamber which is at least one-third of a volution in extent and its surface is marked by rather prominent growth-lines which form broad, shallow, rounded "lobes" as they cross the lateral sides of the conch and broad, shallow, rounded "saddles" as they cross the ventral side.

Remarks.—This species appears to be much more closely related to the form from the Middle Permian Bitauni beds of Timor that Haniel[23] described as "*Ponanoceras timorense* form. δ" than to any other described species. It differs from that form in that its conch is relatively broader and therefore much more nearly globular and its sutures, though strikingly similar in general plan, have less strongly digitate lobes (see Pl. 39, figs. 21 and 22). The degree of digitation of the lobes, however, increases progressively during the ontogenetic development in this genus, and the fact that the holotype of our species is much smaller than the Timor form may account for at least part of the apparent difference. In any case, the general similarity of the sutures of these two species indicate that they are closely related and are not greatly different in age.

Occurrence.—"Goniatite beds" of phosphatic shale member of Phosphoria formation, on the south side of Raymond Canyon, Sublette Range, westernmost Wyoming.

Types.—State University of Iowa, 706 (holotype), 707 (specimen referred with question to this species).

Genus GASTRIOCERAS Hyatt

With the exception of six specimens, all of the numerous ammonoids known from the Phosphoria are clearly congeneric and are probably referable to the genus *Gastrioceras* s. l., of which the genotype is *G. listeri* (Martin) of the Lower Coal Measures of England and possibly Belgium, Germany, and Arkansas. So many forms have been referred to this genus that it has become more or less unwieldy and there is a growing tendency to subdivide it. Although this has been done in part, the results achieved have not been all that could have been wished for, and rather than establish a new genus or subgenus on inadequate data, we propose to use the generic name *Gastrioceras* in a rather broad sense but to call attention to the fact that all of our specimens belong in what Böse[24] called the "*Group of Gastrioceras zitteli* Gemm." This more or less compact group of ammonoids is widespread in the Permian and it consists of forms which are characterized by their subdiscoidal, slightly involute, rather widely umbilicated, longitudinally lirate conchs and fairly simple sutures. With the exception

[23] Haniel, C. A., Die Cephalopoden der Dyas von Timor: *Pal. von Timor*, Lieferung 3, 6, p. 98, text fig. 28, pl. 5, figs. 5*a*, 5*b*, 1915.

[24] Böse, Emil, The Permo-Carboniferous ammonoids of the Glass Mountains, West Texas, and their stratigraphical significance: *Texas Univ., Bull.* 1762, 1917, p. 85 [1919].

of surface ornamentation, which is hardly to be credited with generic or subgeneric significance, *G. zitteli* and its affines do not appear to differ materially from *Goniatites spirorbis* Phillips of the Mississippian of England, which is the genotype of *Nomismoceras*, and perhaps our specimens should be referred to that genus rather than to *Gastrioceras*. Anyhow, the group to which they belong includes *Gastrioceras zitteli* Gemmellaro, *G. roemeri* Gemmellaro, *G. sosiense* Gemmellaro, *G. waageni* Gemmellaro, and possibly *G. hirsutum* De Gregorio of the Sosio beds of Sicily; *G. roadense* Böse and "*Gastrioceras sp.* nov. indet." Böse[25] of the Word formation of Texas; *G. altudense* Böse of the Hess-Leonard formation of Texas; *G. jossae* (de Verneuil), *G. suessi* Karpinsky, and "*Gastrioceras* sp. indet." Karpinsky[26] of the Artinskian of the Urals; possibly "*Gastrioceras roemeri* Gemm.?" Vogl[27] of the Mrzla-Vodica beds in Croatia; "*Gastrioceras* sp." Girty[28] of the Delaware Mountain formation of Texas; "*Gastrioceras* nov. sp." Frech[29] of the Permian near Ning-kwo-hsiën in China; and "*Gastrioceras* cf. *zitteli*" Frech[30] of the Permian of Tshau-Tiën, China. Most of these forms apparently are of Middle Permian age, but some of them came from the upper part of the Lower Permian. However, the Phosphoria specimens appear to be more similar and, therefore, presumably more closely related to *G. roadense*, *G. sosiense*, and *G. roemeri* than to any of the other species and all three of these forms are Middle Permian in age and are believed to have been contemporaneous. R. E. King[31] called attention to the similarity of *G. roadense* of the Word formation and *G. simulator* of the Phosphoria, and we have found from direct comparisons that small specimens of *G. roadense* (or a very closely related form) from the equivalent of the Word in northern Mexico are so similar to equisized specimens of *G. simulator* that, were it not for a difference in the relative widths of the conchs, they would be difficult to distinguish.

The specific subdivision of the forms that are referred to *Gastrioceras* is just as difficult as is the generic. Altogether we have well over a hundred specimens which we are placing in this genus, and we can divide them into four distinct groups; one of these is characterized by its moderately small size, prominent transverse sinuous constrictions, and a low, broad ventral lobe in its sutures; a second is similar but has very distinct short transverse ribs on its umbilical shoulders; a third is somewhat larger, its umbilical shoulders are smooth, and the ventral lobe of its sutures is relatively narrow; a fourth is still larger and, though in general similar to the third, differs particularly in that the ventral lobe of its sutures is exceedingly broad and its umbilicus is narrow. All of these differences are minor but they are constant and are easily recognized. We are somewhat in doubt as to whether we are dealing with four varieties of a single species or four distinct species. After due consideration we have decided to regard them tentatively at least as distinct species even though all of them came from the same horizon, but we recognize that

[25] Böse, Emil, *op. cit.*, pp. 90–92, pl. 3, fig. 7, 8.

[26] Karpinsky, A., Über die Ammoneen der Artinsk-Stufe und einige mit denselben verwandte Formen: *Mém. l'Acad. Imp. des Sci. de St. Pétersbourg*, sér. 7e, tome 37, no. 2, pp. 54–55, pl. 3, figs. 2*a*–2*c*, 1889.

[27] Vogl, Viktor, Die Paläodyas von Mrzla-Vodica in Kroatien: *Jahrb. k. Ungar. geol. Reichanstalt*, Bd. 21, pp. 160, 165, 1913.

[28] Girty, G. H., The Guadalupian fauna: *U. S. Geol. Survey, Prof. Paper* 58, pp. 500–501, pl. 29, figs. 22, 22*a*, 1908.

[29] Frech, Fritz, Ueber palaeozoische Faunen aus Asien und Nordafrika: *Neus. Jahrb. f. Min., Geol. und Pal.*, Jahrg. 1895, Bd. 2, pp. 55–56, text fig. 2, 1895.

[30] Frech, Fritz, Untere Neodyas (früher Carbon) von Tshau-Tiën (im Ta-Pa-Shan-Profil), Provinz Sz'-Tshwan: in *China* by F. V. Richthofen, Bd. 5, p. 140, pl. 25, fig. 7, 1911

[31] King, R. E., The geology of the Glass Mountains, Texas, Part II, Faunal summary and correlation of the Permian formations with description of Brachiopoda: *Texas Univ., Bull.* 3042, p. 32, 1930.

others may prefer to regard them as varieties of *Gastrioceras simulator*.

GASTRIOCERAS SIMULATOR Girty
Plate 39, figures 11–14

Gastrioceras simulator GIRTY [part], *1910*, U. S. Geol. Survey, Bull. 436, pp. 52–54, pl. 7, figs. 11–12*a* [not figs. 13, 13*a*].

The original description of this species by Girty is very thorough, but we are of the opinion that all of the specimens on which it is based are not conspecific. We are, therefore, choosing the only specimen figured by Girty that retains its sutures as the holotype of the species; this specimen is represented by Girty's figure 11, which is reproduced as figure 11, Plate 39, of the present publication. The privilege of studying this specimen has been accorded us and we wish to take this opportunity to express our sincere appreciation for this favor.

The holotype of this species is an internal mold to which considerable portions of the test adhere. It doubtlessly is almost complete but the adepertural portions of the conch are not retained and only one side of the specimen has been freed from the matrix. The maximum diameter of this specimen measures about 13 mm.; the diameter at right angles to this and across the umbilicus measures about 11 mm. At the adoral end of the holotype the conch is about $8\frac{1}{2}$ mm. wide and 6 mm. high. At the adapical end of the outer volution, the conch is about $4\frac{1}{2}$ mm. (estimated) wide and about $2\frac{1}{4}$ mm. high. The whorls are depressed dorsoventrally and are helmet-shaped in cross section. They are somewhat flattened laterally but are broadly rounded ventrolaterally and ventrally and are impressed dorsally to about one-third their height.

The umbilicus is moderately large and the umbilical shoulders of all of the inner volutions are exposed. The diameter of the umbilicus is equal to a little more than one-third that of the specimen; the umbilicus of the holotype attains a maximum diameter of about $3\frac{1}{2}$ mm. The umbilical shoulders are so abrupt as to appear almost angular but on the internal mold they are less nearly angular. The umbilical walls of each volution are nearly straight (very slightly convex) and they are almost at right angles to the flattened lateral sides of the conch.

The living chamber of the holotype is not complete adaperturally but it must have been at least one volution in length. Growth-lines on the holotype show that the aperture is marked ventrally by a prominent, rather narrowly rounded hyponomic sinus, ventro-laterally by equally prominent crests, and laterally by sinuses. On the impressed dorsal zone the growth-lines are transverse to the long axis of the conch but are slightly sinuous. A remarkably well preserved paratype retains the aperture and it is being figured; this complete specimen attains a maximum diameter, measured from the apertural margin to the opposite side of the specimen, of about $14\frac{1}{2}$ mm., and a maximum width and height of conch of about $8\frac{1}{2}$ mm. and $6\frac{1}{4}$ mm., respectively.

The surface of the conch is marked by about fifty prominent longitudinal lirae which are not quite as wide as the intervening grooves. The umbilical walls are not lirate. The umbilical shoulder is marked by a prominent, broad, shallow, rounded groove which is bordered on either side by an exceptionally prominent lira. Growth-lines are much less prominent than the longitudinal lirae but on well preserved specimens like the holotype they are clearly discernible. Traces of the lirae (but not the growth-lines) are present on the internal mold. On the innermost volutions of the conch the longitudinal lirae become obsolete but the growth-lines are very prominent and a suggestion of umbilical nodes is present. On the internal mold, but not the exterior of the conch, there are prominent, sinuous constrictions; about three of these occur on each volution. They form slight ventral "lobes," rounded ventrolateral "saddles," and broader, rounded lateral "lobes."

A complete suture of this species consists of a total of eight primary lobes and eight primary saddles. Three of the lobes are internal, three are external, and two are intermediate in position as they are located on the umbilical walls. The primary saddles are equally distributed between the internal and external portions of the suture. The ventral lobe is short and broad and it is subdivided by a short, broad, U-shaped median saddle which in turn is divided by a low, broad, rounded tertiary lobe; the major subdivisions (secondary lobes) of the ventral lobe are narrower than the intermediate secondary saddle and they are very narrowly rounded. The external saddle is short, broad, broadly rounded and asymmetrical. The first lateral lobe is short, broad, and broadly rounded. The first lateral saddle is very broad and shallow and it is very asymmetrical. The lobe on the umbilical wall is low and broad and almost angular. The dorsal lobe is long, narrow, and rounded; its sides are almost parallel. The saddles on either side of the dorsal lobe are U-shaped, and the internal lateral lobes, which are somewhat broader and almost as long as the dorsal lobe, are more or less V-shaped but are narrowly rounded. The saddles which separate the internal lateral lobes from the small lobes on the umbilical walls are depressed-U-shaped, very broad, and very asymmetrical.

Remarks.—Girty figured three of the cotypes of this species all of which are now available for study by us. The specimen represented by Girty's figures 12 and 12*a* appears to be conspecific with the above described holotype, but that represented by his figures 13 and 13*a* should be referred to *Gastrioceras stenolobatum*, described below. Girty compared this species with *G. caneyanum* Girty but the relationship is not close. However, this species is closely related to the forms described below as *G. williamsi*, *G. stenolobatum*, and *G. brevicostatum*. *G. williamsi* is much larger; the ventral lobe of the sutures of *G. stenolobatum* is much narrower than is that of *G. simulator;* and the umbilical shoulders of *G. brevicostatum* bear prominent short ribs. Immature representatives of *G. roadense* Böse are similar to this species but their conchs are narrower and at maturity are many times larger.

Occurrence.—"Goniatite beds" of phosphatic shale member of Phosphoria formation in Layland Tunnel Canyon, Raymond Canyon, and Coal Canyon, Sublette Range, westernmost Wyoming. The holotype came from Layland Tunnel Canyon and the figured paratype from Raymond Canyon where this species is fairly abundant.

Types.—U. S. Geological Survey, 1722 (holotype) and 1724 (figured paratype); State University of Iowa, 708 (plesiotypes).

GASTRIOCERAS BREVICOSTATUM
Miller and Cline, n. sp.
Plate 39, figures 1–4

We have five conspecific specimens from the Phosphoria which, though closely related to *Gastrioceras simulator* Girty, appear to be specifically distinct from it, and we propose the name *Gastrioceras brevicostatum* for them, for one of their most distinctive characters is the possession of short ribs on the umbilical shoulders. One of the specimens is more nearly complete than the others and we are therefore designating it as the holotype.

Conch moderately small, subdiscoidal, and ammoniticonic. Whorls, which are helmet-shaped in cross section, are slightly flattened laterally, broadly rounded ventrally and ventro-laterally, and impressed dorsally. The holotype is an internal mold representing all of the phragmacone and much of the living chamber, but it is not complete adaperturally. Its maximum diameter measures about 12 mm.; the diameter at right angles to this measures about 10 mm. At the adapertural end of this specimen the conch is about 7½ mm. wide and about 5 mm. high; at the adapical end of the outer

volution the width and height of the conch are about $4\frac{3}{4}$ and $2\frac{3}{4}$ mm., respectively. The whorls are impressed dorsally to about one-fourth their height. The living chamber in this species is at least half a volution in length.

The umbilicus is moderately large and is deep; the umbilical shoulders of all volutions are exposed. The diameter of the umbilicus is equal to about one-third that of the specimen, and the maximum diameter of the umbilicus of the holotype measures about $3\frac{3}{4}$ mm. The umbilical shoulders are rounded; they bear small but prominent, rounded, short, transverse ribs or elongate nodes, which are considerably narrower than the intervening spaces; there are about twenty of these ribs to the volution. They are equally prominent on all of the types, which range in diameter from about 4 mm. to about 15 mm. They gradually decrease in prominence both dorsally and ventrally and they do not extend far beyond the umbilical shoulders. The umbilical walls are of course stepped, and those of each whorl are almost straight (very slightly convex) and are approximately perpendicular to the flattened lateral sides of the conch.

The surface of the conch is marked by about fifty narrowly rounded longitudinal lirae which are much narrower than the intervening concave spaces. The umbilical walls apparently are not lirate but this needs verification. Traces of the longitudinal lirae are preserved on the internal mold. The surface of the test is also marked by growth-lines, which are much less prominent than the longitudinal lirae; these indicate that the aperture bore a broad narrowly rounded hyponomic sinus, similarly shaped ventro-lateral crests, and rounded lateral sinuses. The conchs of representatives of this species are marked by very prominent, sinuous, transverse, rounded constrictions of which there are about five to the volution; these form slight ventral "lobes," shallow ventro-lateral "saddles" and broad lateral "lobes."

Each external suture consists of a total of three primary lobes and four primary saddles; there is an additional lobe on each umbilical wall. The ventral lobe is short and broad and it is divided medianly by a short, very broad, secondary saddle which in turn is subdivided by a small, rounded, median tertiary lobe; the major prongs (secondary lobes) of the ventral lobe are asymmetrical and they are bluntly pointed. The external saddle is essentially U-shaped but its sides are not straight and it is somewhat asymmetrical. The first lateral lobe is short, broad, and bluntly pointed. The first lateral saddle is very broad and shallow, undivided, and very asymmetrical. The lobe on the umbilical wall is small, angular, and asymmetrical. The internal sutures are not visible on any of the types but they doubtlessly are not greatly different from those of *Gastrioceras simulator* described above.

Remarks.—This species is very closely related to *Gastrioceras simulator* Girty and the forms described below as *G. stenolobatum* and *G. williamsi;* however, its prominent umbilical ribs or nodes differentiate it readily from them. It should not be assumed that these ribs are merely an adolescent character for the preserved part of one of the paratypes attains a diameter of about 15 mm. and its umbilical shoulders are ribbed throughout.

Occurrence.—"Goniatite beds" of phosphatic shale member of Phosphoria formation on south side of Raymond Canyon, Sublette Range, westernmost Wyoming.

Types.—State University of Iowa, 709 (holotype) and 710 (paratypes).

GASTRIOCERAS STENOLOBATUM
Miller and Cline, n. sp.

Plate 39, figures 5–7

Gastrioceras simulator [part] GIRTY, *1910*, U. S. Geol. Survey, Bull. 436, pp. 52–54, pl. 7, figs. 13, 13*a* [not figs. 11–12*a*].

There occurs in the Phosphoria formation a species which is closely related to *Gastrioceras simulator* and its affines but

differs from them particularly in that the ventral lobe of its sutures is narrow rather than broad. We propose the name *Gastrioceras stenolobatum* for this form. Our collection contains six representatives of it but one of them is more nearly complete and better preserved than the others and we are therefore designating it as the holotype.

Form subdiscoidal as conch is ammoniticonic in its mode of growth and is only slightly depressed dorso-ventrally. Whorls are flattened laterally, broadly rounded ventro-laterally, rather narrowly rounded ventrally, and impressed dorsally. The holotype is a well preserved internal mold to which portions of the test adhere. It represents all of the phragmacone and about two-thirds of a volution of the living chamber but it is not complete adorally. Its maximum diameter, measured from the adoral end of the preserved part of the venter across the umbilicus to the opposite side of the specimen, is about 21½ mm.; the diameter at right angles to this and across the umbilicus measures about 17½ mm. At the adoral end of the holotype the conch is about 11½ mm. wide and about 9½ mm. high, whereas at the adapical end of the outer volution it is only about 6½ mm. wide and about 5 mm. high; these measurements indicate clearly that the conch expands orad very rapidly. The living chamber is at least five-sixths of a volution in length.

The umbilicus is large and deep and the umbilical shoulders of all volutions are exposed; the diameter of the umbilicus is equal to about one-third that of the specimen and the umbilicus of the holotype attains a maximum diameter of about 8 mm. The umbilical shoulders are abrupt but on both the exterior of the test and on the internal mold they are very narrowly rounded. The umbilical wall is stepped and that of each volution is nearly straight (slightly convex) and is almost perpendicular to the flattened lateral side of the conch.

The surface of the test is marked by about sixty-five prominent, narrow, narrowly rounded, longitudinal lirae which are considerably narrower than the intervening spaces. The umbilical shoulders and probably the umbilical walls are not lirate. Traces of these lirae are clearly discernible on the internal mold. Sinuous growth-lines are also present on the conch of this species; they indicate that the aperture was marked ventrally by a prominent, narrowly rounded hyponomic sinus, ventro-laterally by similar but more broadly rounded crests, and laterally by broader, shallower sinuses. On the internal mold traces of the increments of growth are much more prominent than are traces of the longitudinal lirae and in some cases they simulate the sinuous transverse constrictions which are so prominent on closely related species like *Gastrioceras brevicostatum* and *G. simulator;* however, they lack the regular spacing which is characteristic of those constrictions.

Each external suture consists of a total of three primary lobes and four primary saddles; there is in addition a small lobe on each umbilical wall. The ventral lobe is relatively narrow for this genus; it is divided medianly by a prominent secondary saddle which is constricted near its mid-height and which, in turn, is subdivided by a low, broad, rounded tertiary lobe; the prongs (secondary lobes) of the ventral lobe are considerably narrower than the intermediate secondary saddle and they are more or less tongue-shaped but are sharply pointed and somewhat asymmetrical. The external saddle is much wider than the ventral lobe and it is U-shaped but is slightly asymmetrical. The first lateral lobe is broad and is somewhat V-shaped but its sides are convex and it is slightly asymmetrical. The first lateral saddle is very broad, moderately deep, and distinctly asymmetrical. The small lobe on the umbilical wall is V-shaped but its sides are concave. The internal sutures of this species are not known but they doubtlessly are not greatly different

from those of *Gastrioceras simulator*, described above.

Remarks.—This species can be readily differentiated from all congeneric forms that we found in the Phosphoria by the narrowness of the ventral lobe of its sutures. It is perhaps more closely similar to *Gastrioceras williamsi* than to any other described species but its relatively wide umbilicus makes it possible to differentiate representatives of these two species even when the nature of the sutures can not be ascertained.

Occurrence.—"Goniatite beds" of phosphatic shale member of Phosphoria formation on south side of Raymond Canyon, Sublette Range, westernmost Wyoming.

Types.—State University of Iowa, 711 (holotype) and 712 (paratypes); U. S. Geological Survey, 1723 (paratype).

GASTRIOCERAS WILLIAMSI
Miller and Cline, n. sp.

Plate 39, figures 8–10

Gastrioceras? sp. GIRTY, *1910*, U. S. Geol. Survey, Bull. 436, p. 54, pl. 7, fig. 14.

This species is being based on two specimens. The better preserved of these is the specimen that was figured by Girty in 1910 as "*Gastrioceras?* sp."; it is designated as the holotype. Both of the types are well-preserved internal molds but neither is complete adaperturally.

Conch moderate in size, subdiscoidal, and ammoniticonic. Whorls are very slightly depressed dorso-ventrally, narrowly rounded ventrally, broadly rounded ventro-laterally, flattened laterally, and impressed dorsally. The maximum diameter attained by the holotype, which represents all of the phragmacone and one complete volution of the living chamber, measures about 23 mm. but the paratype appears to have attained a diameter of at least 30–35 mm. At the adoral end of the holotype the conch is about 11 mm. high and 12½ mm. wide and it is impressed dorsally to almost two-fifths its height. At the adapical end of the outer volution of the holotype the conch is about 6 mm. high and about 8 mm. wide. The living chamber in this species is at least one volution in length.

The umbilicus is moderately small and its diameter is equal to only about one-fourth that of the specimen; the maximum diameter attained by the umbilicus of the preserved portion of the holotype measures about 5½ mm. On the internal mold the umbilical shoulders are abrupt but are very narrowly rounded. The umbilical walls of at least the outer volution of the holotype are slightly convex and are moderately steep.

The surface of the internal mold is marked by prominent traces of growth-lines and by faint traces of longitudinal lirae. The growth-lines are sinuous and they indicate that the aperture was marked ventrally by a moderately deep, narrowly rounded hyponomic sinus, ventro-laterally by broad rounded crests, and laterally by broad, shallow, rounded sinuses.

Each complete suture consists of a total of eight primary lobes and eight primary saddles; three of these lobes are external, three are internal, and two are located on the intermediate zones (umbilical walls). The primary saddles are equally distributed between the internal and the external portions of the sutures. The ventral lobe is short and broad and it is divided medianly by a more or less U-shaped secondary saddle which in turn is subdivided by a very small, rounded, tertiary lobe; the major prongs (secondary lobes) of the ventral lobe are larger than the intermediate secondary saddle and they are bluntly pointed and slightly asymmetrical. The external saddle is somewhat U-shaped but it is very asymmetrical. The first lateral lobe is short, broad, bluntly pointed, and asymmetrical. The first lateral saddle is very broad and shallow and is almost symmetrical. The lobe on the umbilical wall is essentially symmetrical and it is more or less V-shaped but its sides are concave. The dorsal lobe is much smaller than the ventral lobe and is tongue-shaped but is very acuminate; the saddles on either

side of it are U-shaped. The internal lateral lobes are much shorter than the dorsal lobe and are tongue-shaped; the saddle which separates the internal lateral lobe from the lobe on the umbilical wall (described above) is broad and broadly rounded.

Remarks.—The relatively large size, small umbilicus, narrowly rounded venter, and recognizable differences in the sutures distinguish this species from *Gastrioceras simulator;* the absence of umbilical nodes or ribs distinguishes it from *G. brevicostatum;* and its relatively small umbilicus and the wide ventral lobe of its sutures distinguish it from *G. stenolobatum.*

Occurrence.—"Goniatite beds" of phosphatic shale member of Phosphoria formation in Layland Tunnel Canyon and Raymond Canyon, Sublette Range, westernmost Wyoming. The holotype came from Layland Tunnel Canyon and the paratype from Raymond Canyon.

Types.—U. S. Geological Survey, 1725 (holotype); State University of Iowa, 713 (paratype).

Genus GONIATITES de Haan

"GONIATITES? sp."

Goniatites? sp. GIRTY, *1910,* U. S. Geol. Survey, Bull. 436, pp. 54–55.

With the possible exception of a single fragment of a *Gastrioceras* which we picked up in the regolith, the only ammonoid known from the Phosphoria that did not come from the so-called "goniatite beds" is a single small specimen which Girty described as *"Goniatites?* sp.," using the generic name in its old broad sense as he was not able to determine the precise generic affinities of the specimen. Girty did not illustrate this specimen and unfortunately it has been misplaced. Nevertheless, we are convinced that it is quite distinct from all of the forms in the collection we are studying and we are therefore reproducing Girty's concise description, which is all of the information available in regard to this form.

"This term [*Goniatites?* sp.] is employed for a single specimen which, though indeterminate, is probably deserving of mention. It is very small and discoidal, with a diameter of about 1.5 mm. and a thickness of perhaps 0.25 mm. The volutions are six in number, scarcely enlarging at all, complanate, and barely in contact. The initial point is a bulbous enlargement having a greater diameter than the whorl beyond.

"In its present condition no sutures are shown, but it must be presumed to have possessed them if, as I suppose, it is a larval goniatite. The genus can not, of course, at this time be fixed. Professor Smith has figured a similar form as *Goniatites calyx*[32] and the young stages of *G. caneyanus* present a similar appearance."

Occurrence.—Massive gray limestone bed (immediately above the so-called "goniatite beds") of phosphatic shale member of Phosphoria formation, Coal Canyon, Sublette Range, westernmost Wyoming.

[32] Smith, J. P., *U. S. Geol. Survey, Mon.* 42, pl. 18, figs. 6, 9, etc., 1903.

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THE GRAPTOLITES OF THE VIOLA LIMESTONE[1]

RUDOLF RUEDEMANN and CHARLES E. DECKER

ABSTRACT

This paper deals with the dscription, illustration, and correlation of thirty species and varieties of graptolites found in the Viola limestone of the Arbuckle and Wichita Mountains and Criner Hills of Oklahoma. One new species and three new varieties are described. A table showing the distribution of the different varieties, a short summary, and a brief bibliography are included.

While the junior author is responsible for field work, assembling the material and for stratigraphy and conclusions, he is greatly indebted to Dr. Rudolf Ruedemann for his assistance in identifying, drawing and describing the graptolites, for use of his equipment and published articles and for his collaboration in this paper. He is also indebted to the National Research Council for a grant of funds to assist in completing field work and to pay part of the expense of taking the extended collections to the New York State Museum at Albany for study, to the New York State Museum for the many courtesies extended during the two months of study, and especially to Mr. E. J. Stein and J. W. Stovall for their skill in photographing the graptolites. Acknowledgment for assistance in the field is made to John Fitts, Rex McGehee, Norval Ballard, Ross Maxwell, and Everett Orr.

DESCRIPTION OF SPECIES

Order 1 DENDROIDEA Nicholson
Family DENDROGRAPTIDAE Roemer

DESMOGRAPTUS Hopkinson, 1875

DESMOGRAPTUS OKLAHOMENSIS
Ruedemann and Decker, n. sp.
Plate 40, figures 1, 1*a*

Complete rhabdosome not known, probably flabelliform as in most of the congeners. Meshwork fairly regular, the branches subparallel, but little undulating fusing at the points of contact and forming elongate elliptic meshes. Branches closely arranged, numbering about sixteen in 10 mm. transversely and six to eight longitudinally. The branches are about 0.3 mm. wide expanding to 0.6 and 0.8 where they coalesce. The meshes are 0.5–0.7 mm. wide and twice as long as wide. The dissepiments where present are as wide as the branches. The thecae are arranged uniserially at one side of the branch, their free distal parts (about 0.4–0.6 mm. long) tubular diverging upward at an angle of 50°, numbering sixteen to twenty in 10 mm. Bithecae have not been observed.

Horizon and locality.—Ordovician, Viola limestone (zone 6) 50 feet above base at Witch Hole, 4 miles southwest of Bromide, Oklahoma. Sec. 2, T. 2 S., R. 7 E. Collector, C. E. Decker, 1931.

Remarks.—This species is based on a mere fragment. The latter shows, however, the character of the meshes and of the thecae so well that there can be no difficulty in recognizing the species, especially as there is only one other form of the genus known of similar age, viz.

[1] The Viola limestone was named for a former town of Viola about 4½ miles southwest of Bromide. Only two or three old shacks mark the site of the old town, near which was the outcrop of this limestone.

D. tenuiramosus Ruedemann, from the Normanskill shale and this is readily distinguished by its thinned, more widely spaced branches, and much longer meshes. This species is particularly interesting in that it adds a second early species of Ordovician age to a genus which is most largely represented in the Devonian.

Holotypes of this new species and of the three new varieties, and plesiotypes of the rest of the forms described are deposited in the museum of invertebrate paleontology at the University of Oklahoma.

MASTIGOGRAPTUS Ruedemann, 1908

MASTIGOGRAPTUS cf. CIRCINALIS Ruedemann

Plate 40, figures 2, 2*a*, 3, 3*a*

Mastigograptus circinalis RUEDEMANN, *1908*, New York State Mus., Mem. 11, p. 222, pl. 10, fig. 3; pl. 12, figs. 7, 8.

Original description.—Rhabdosome small, consisting of very thin (0.2 mm.) filiform extremely flexuous stem and equally flexuous, still thinner alternating branches dividing repeatedly into long branches of higher orders, the process of subdivision continuing until almost invisible, long hairlike branches result. Stems and branches possess a strong tendency to become, each independently, enrolled. Thecae apertures are seen as fine circular pits, numbering nine to eleven in the space of 10 mm.

This curious little form of *Mastigograptus* was found in the Canajoharie shale at the Rural cemetery near Albany, erroneously designated as Utica shale in the earlier publication.

The Viola limestone of Oklahoma has afforded fragments of a very thin (0.2 mm.) flexuous *Mastigograptus* that may well be identified with this species as positively as the fragmentary character of the material allows. It comes from the base, sec. 35, T. 5 S., R. 1E., Rock Crossing, Criner Hills. C. E. Decker, collector, 1931. It is worth noting that one specimen shows two projecting thecae, as those described cf. *M. tenuiramosus*.

MASTIGOGRAPTUS GRACILLIMUS (Lesquereux)

Psilophyton gracillimus LESQUEREUX, *1878*, Am. Philos. Soc., Proc., vol. 17, p. 164, pl. 4, fig. 2.

Dendrograptus (*Psilophyton*) *gracillimus* WALCOTT, *1879*, Advance Sheet of Albany Inst., Trans., p. 21; *1883*. Albany Inst., Trans., vol. 10, p. 21.

Dendrograptus gracillimus ULRICH, *1885*, Cat. Foss. Cin. Gr. O., Ind., and Ky.

Dendrograptus gracillimum JAMES, *1885*, Cincinnati Soc. Nat. Hist., Jour., p. 160, pl. 9, fig. 5.

Dendrograptus gracillimus JAMES, *1892*, Cincinnati Soc. Nat. Hist., Jour., p. 149.—HARPER AND BASSLER, *1896*, Cat. Foss. Tr. and Cin. periods in vicinity of Cincinnati, Ohio.—GURLEY, *1896*, Jour. Geology, vol. 4, p. 299.—NICKLES, *1901*, Cincinnati Soc. Nat. Hist., Jour., vol. 20, p. 68.

Mastigograptus gracillimus RUEDEMANN, *1908*, New York State Mus., Mem. 11, pp. 219–221, pl. 10, fig. 2; *1923*, New York State Mus., Bull. 262, p. 43, pl. 5, fig. 4; *1925*, Systematic Paleontology, no. 1, p. 43, pl. 5, fig. 4, and text figure 25.

The type of the species came from the Cincinnati beds from the bed of the Licking River opposite Cincinnati near Covington, Kentucky, and Lesquereux considered it a plant and described it as follows:

> Stem very slender, dichotomously branching, smooth or naked half round, slightly channeled in the length, branches numerous of various length, filiform. The stem is scarcely 1 mm. thick at the base; the upper branches curved as from a spiral unfolding, are slender gradually alternated and capilliform, or of the thickness of a thin thread at their extremities.

It is thought that the type probably went with Hall's collection to the University of Chicago where it has not since been recognized.

Topotypes collected from the original locality have been illustrated and described by Ruedemann as follows:

> A stem which has a diameter of 0.8 plus mm. is so little compressed that it appears to have been very solid. Its surface is smooth and fails to show traces of growth lines. The branches which are given off monopodially have a thickness that is a little greater than

that of *tenuiramosus* and are seen in one specimen to contract and expand regularly about eight times in 10 mm. from 2 mm. to 2.5 mm., producing an apparent jointed structure.

This jointing is thought to represent either the ends of thecae or the bases of branches, with the conclusion that it is probably the latter.

Fragments referred to this species have been found 50 feet above the base of the Viola limestone at the Witch Hole, sec. 2, T. 2 S., R. 7 E., and near the eroded base of the Viola at Rock Crossing, sec. 35, T. 5 S., R. 1 E., and at the base of zone 11 at the base of the Viola in sec. 2, T. 1 N., R. 6 E., on the P. A. Norris Ranch, in Oklahoma. Also, it has been found at several horizons in the Frankfort shale near Rome, New York.

Order II GRAPTOLOIDEA Lapworth

Suborder A GRAPTOLOIDEA

AXONOLIPA Frech em. Ruedemann

Family LEPTOGRAPTIDAE Lapworth

LEPTOGRAPTUS Lapworth, 1873

LEPTOGRAPTUS ANNECTANS (Walcott)

Plate 40, figures 4, 4*a*

Graptolithus annectans WALCOTT, *1883*, Albany Inst., Trans., vol. 10, (Advance Sheet, *1879*, pp. 20, 35; pl. 1, figs. 2, 2*a*).

Graptolithus tenuis? Portlock, ULRICH, *1880*, Cat. Foss., Occur. Cin. Gr., etc.

Leptograptus annectans LAPWORTH, *1886*, Roy. Soc. Can., Trans., vol. 4, p. 183.—AMI, *1893*, Can. Rec. Sci., vol. 9, p. 180.—GURLEY, *1896*, Jour. Geology, vol. 4, p. 296.—RUEDEMANN, *1908*, New York State Mus., Mem. 11, p. 264, pl. 14, fig. 5; *1925*, New York State Mus., Bull. 262, p. 50, pl. 6, figs. 1–8.

This species has been described by Ruedemann as follows:

Rhabdosome of medium size, branches attaining a length of 50 plus mm. and showing gentle double curvature (first concave and then convex), gradually increasing in width from 0.3 mm. to about 1 mm.; angle of divergence 270°–290.° Axil wide, sicula small. (1.3 mm.), provided with small virgella. Four primary thecae approximately horizontal, bearing small mucros. Thecae numbering 10 in 10 mm. with slight variations (11 to 12 near center); overlapping about one-half their length, inclined 15°; the vertical walls of the free portions of the thecae first straight, slightly convex near the aperture; the latter is slightly introverted, the excavation shallow.

This form has been found near the base of zone 10 about 100 feet above the base of the Viola limestone on the east side of U. S. Highway 77, 2 miles north of Springer, Oklahoma. This species is known from rocks of Utica age near Cincinnati, Ohio, and four varieties of the species occur in the upper Utica shale at Deerfield near Utica and at Holland Patent, New York.

LEPTOGRAPTUS CAPILLARIS Caruthers

Non *Nemagrapsus capillaris* EMMONS, *1855*, Am. Geology, vol. 1, p. 109, pl. 1, fig. 7.

Cladograpsus capillaris CARUTHERS, *1868*, Geol. Mag., vol. 5, p. 130, pl. 5, fig. 7.

Non *Nemagraptus capillaris* HOPKINSON, *1875*, Quart. Jour. Geol. Soc., vol. 31, p. 34, figs. 2*a–b*.

Leptograptus capillaris LAPWORTH, *1876*, Cat. West Scot. Foss., pl. 3, fig. 72.—ELLES and WOOD, *1901–1918*, vol. 1, p. 112, figs. 4*a–d*.

Stipes commonly 4–8 cm. in length, slender and very much flexed, widening from a breadth of about 0.2 mm. near the sicula to a maximum of 0.5 mm. in the more distal part of the stipes. Sicula about 1.7 mm. in length but rarely complete. Thecae eight to ten in 10 mm. on inner or outer side of curve, inclined at a very low angle and free about one-half of their length. Apertural margins very narrow, inconspicuous.

The stipes are always more or less slender and threadlike; they never exceed 0.5 mm. in width. Their curvature is very pronounced and extremely characteristic, each stipe frequently describing the greater part of a circle in the course of its growth in an upward or downward direction; the curved stipes may cross each other, or may be coiled upon each other, or upon themselves, so that there is a great variety in the ultimate form attained, the only constant feature being the excessive

amount of curvature. The sicula is 2 mm. in length and very slender, but is seldom completely preserved.

The characters of the thecae are usually hard to determine; owing to the excessive tenuity of the stipe and its curvature, they are but rarely seen in continuous succession, and their apertures are so minute, except in the case of the 1^1 and the 1^2 that they are generally visible merely as slight notches in the wall of the stipe. The apertures of the 1^1 and 1^2 are, however, conspicuous and mucronate. The mature thecae have a length of about 2 mm. and are in contact for one-half to one-third of their length (Elles and Wood).

L. capillaris may be readily distinguished from all other *Leptograpti* by the extreme tenuity of its stipes and their pronounced curvature.

Horizon.—Lower Hartfell, S. Scotland, etc. Abundant in upper zones of lower Hartfell. Some specimens too poor to draw were found in the Viola limestone in zone 10 on U. S. Highway 77, 2½ miles north of Springer, Oklahoma.

LEPTOGRAPTUS FLACCIDUS Hall var. MACER Elles and Wood

Plate 40, figures 5, 5*a*, 6

ELLES and WOOD, *1901–1918*, British Graptolites, vol. 1, p. 110.

Another variety of *L. flaccidus* characterized by the tenuity of its stipes has also been recognized, and to it the name var. *macer* has been given. Its stipes are 5 to 7 cm. or more in length. They are commonly directed upward and outward at a wide angle of about 250° and their slight curvature is variable in direction and amount; they are characteristically narrow, but widen somewhat in a distal direction, having a width at their origin not exceeding 0.3 mm. and a maximum breadth near the distal end of 0.6 mm.

The sicula is a long tapering cone about 2 mm. in length, exclusive of the nema, which is occasionally preserved; the origin of the stipes is basal and the first thecae grow at once obliquely outward, giving a characteristic look to the proximal end; thecae 1^1 and 1^2 are furnished with a small spine.

The thecae are very long and narrow, and are more remote than in any other species of *Leptograptus*. There are six in 10 mm. along the greater part of the length of the stipes, but eight in 10 mm. quite close to the sicula; they have an average length of 2.5 mm. and their apertures occupy about one-half the width of the stipes (Elles and Wood).

Horizon.—Lower Hartfell shales, S. Scotland.

Associates.—*L. flaccidus, L. capillaris, Dip. foliaceus*, var. *vulgatus, Climacograptus tubuliferus* (Elles and Wood).

The variety *macer* is characterized by its long and extremely tenuous stipes which do not exceed 3 mm. in width. The thecae are long and slender, numbering eight in 10 mm. in the sicular region and six in 10 mm. more distally (Ruedemann).

This variety occurs in Great Britain in the zone of *Pleurograptus linearis* in the Hartfell shales. In America it is found in the basal Viola limestone at Rock Crossing in the Criner Hills in Oklahoma, where the slender stipes completely cover the intricately mixed masses of some of the bedding planes. Also, this species occurs widely in the Arbuckle Mountains at West Spring Creek, along U. S. Highway 77, on the West Branch of Sycamore Creek, at the Witch Hole 4 miles southwest of Bromide, at the northwest edge of Bromide, and 2 miles west of the Nebo Store south of Sulphur.

LEPTOGRAPTUS FLACCIDUS (Hall) mut. TRENTONENSIS Ruedemann

Plate 40, figures 7, 8

Leptograptus flaccidus (Hall) mut. *trentonensis* RUEDEMANN, *1908*, New York State Mus., Mem. 11, p. 261, text-figs. 172–175, pl. 14, figs. 6, 7.

This mutation of *L. flaccidus* which occurs in the Normanskill shale is characterized by the wide angle of divergence (220°–240°), the small width (initial width 0.4 to 1 mm. in mature portion) and the long and narrow thecae which number ten to seven in 10 mm. The sicula is 1.5 mm. long. Specimens which fully agree with this mutation, save the length of the sicula which is 2

mm., occur in the Viola limestone of Oklahoma near the base. Other characteristic features are the very long branches of the rhabdosome, the small angle of inclination of the mature thecae, about 15°, the overlapping of the thecae about one-third their length, the four primary thecae diverging horizontally, and ornamented with distinct mucros. The specimen here figured is from Rock Crossing of Hickory Creek in Criner Hills. This variety occurs also at the base of the Viola on the P. A. Norris Ranch and in zone 4 at the northeast edge of Bromide, Oklahoma. These were collected by Prof. C. E. Decker, 1932.

In New York it has been obtained in the Normanskill shale (probably upper), at Glenmont.

DICELLOGRAPTUS Hopkinson, 1871

DICELLOGRAPTUS FORCHAMMERI (Geinitz)

Plate 40, figures 9, 9*a*

Cladograpsus forchammeri GEINITZ, *1852*, Die Graptoliten, p. 31, pl. 5, figs. 28–31.
Didymograpsus forchammeri BAILEY, *1862*, Geol. Soc. Dublin, Quart. Jour., vol. 9, p. 305, pl. 4, fig. 7.
Dicellograpsus forchammeri HOPKINSON, *1871*, Geol. Mag., vol. 8, p. 23, pl. 1, fig. 1.
Dicellograptus forchammeri LAPWORTH, *1876*, Cat. West. Scott. Foss., pl. 4, fig. 88; *1877*, Grapt. Co. Down., pl. 7, fig. 7.—ELLES and WOOD, *1901–1918*, A Monograph of British Graptolites, pp. 150–152, pl. 22, figs. 1*a–d*.

Stipes 14 cm. or more in length, generally straight, widening gradually and persistently from their origin up to 1.2 mm., diverging from a conspicuous sicula at varying but always larger angles (240°–320°). Thecae ten to eight in 10 mm., overlapping for one-third to one-half their length; free outer wall curved, apertural portion introverted. Aperture opening within a shallow pouch-shaped excavation, which occupies one-third the width of the stipe. The stipes frequently attain a great length, and are straight or slightly curved, their curvature at the proximal end being always convex, though it may become concave distally. They are only 0.5 mm. in breadth at their origin, but widen gradually up to 1.2 mm. after which the increase is hardly perceptible. The angle of divergence varies within wide limits. The sicula is always conspicuous within the axil; it has a length of 1.5 mm. exclusive of the stout apertural spine; it becomes very slender toward the apex and merges gradually into the nema (Elles and Wood).[2]

Affinities.—*D. forchammeri* shows resemblances to *D. complanatus* in its general form, but it differs in the character of the proximal end and the introversion of its thecal apertures. The proximal extremity is similar in some respects to that of *D. elegans* but the curvature of the stipes serves to distinguish the two species.

Horizon and localities.—A beautifully symmetrical colony was found in the lower part of the Viola limestone (at Rock Crossing in the Criner Hills of Oklahoma) having the characteristically large sicula with seven thecae on each side. This species occurs commonly in the Glenkiln and Hartfell shales (especially the zone of *Dicranograptus clingani*).

DICELLOGRAPTUS FORCHAMMERI (Geinitz) var. FLEXUOSUS Lapworth

Plate 40, figures 10, 10*a*, 11; Plate 41, figures 1, 2

ELLES and WOOD, *1901–1918*, British Graptolites, pp. 150–152, text figs. 95*a–d*, pl. 22, figs. 2*a–d*.

In addition to the typical *D. forchammeri*, a well-marked variety is occasionally met with, in which the stipes are much narrower and are conspicuously flexed. They are only 0.5 mm. wide at their origin and never exceed 1 mm. in breadth. The sicula is more conspicuous than that of the type form, and is both longer and narrower. The apertural excavation of the thecae is relatively broad, generally occupying about half the width of the stipe; and the spinous outgrowths from the walls of the distal thecae are more fully developed than in the typical form.

The Viola limestone of Oklahoma has

[2] Elles and Wood, British Graptolites, pp. 150–151.

afforded a finely preserved rhabdosome of this species, the basal portion of which is here figured, as well as many fragments. The rhabdosome exhibits fairly curved convex stipes, that become straight distally. They diverge at the base at an angle of 270° and reach a length of 13 cm. The width is small throughout, not exceeding 0.6 mm. In the more strongly flexed and narrower stipes our form agrees with the variety *flexuosus*.

The thecae are those typical of *D. forchammeri*. They number ten to six in 10 mm., becoming a little longer than in the British type (ten to eight), and showing less prominently curved outer walls which are mostly straight or even concave, but possess equally strongly introverted and introtorted apertural portions that are located in pouch-shaped excavations that occupy a little more than one-third the width of the stipe. Like the British species our form shows spinous outgrowths from the walls of the thecae, but only in the proximal region. The thecae, as in the British variety, are long and narrow, reaching 2 mm. in length.

Horizon and locality.—Near base of Viola limestone, 2 miles west of Nebo, Murray County, Oklahoma, sec. 27, T. 2 S., R. 3 E., and Rock Crossing, Criner Hills, Oklahoma. C. E. Decker, collector, 1931.

Remarks.—*Dicellograptus forchammeri* has a long range in Great Britain. According to Elles and Wood, it ranges from zone 9 (of *Nemagraptus gracilis*), corresponding to our lower Normanskill, to zone 13 (zone of *Pleurograptus linearis*) corresponding to our Utica shale, but is most common in zone 12 (zone of *Dicranograptus clingani*) and rare in the first two and the last. The variety *flexuosus*, with which our form agrees, is found only in two horizons; viz: 11 (zone of *Climacograptus wilsoni*) and 12 (zone of *Dicranograptus clingani*). It is most common in the latter.

EXPLANATION OF PLATE 40

FIGS. 1, 1*a*—*Desmograptus oklahomensis* Ruedemann and Decker, n. sp. 1, A fragment of the left side of the colony (×1) showing size and shape of the branches and meshes. 1*a*, Same (×4) showing the shape and arrangement of thecae along the left margin. (p. 303)

2, 2*a*, 3, 3*a*—*Mastigograptus* cf. *circinalis* Ruedemann. 2, 2*a*, Specimens from near base of Viola at Rock Crossing, Spring Creek, Criner Hills (×4 and ×8). 3, 3*a*, Smaller fragments from same horizon and locality (×4 and ×8). (p. 304)

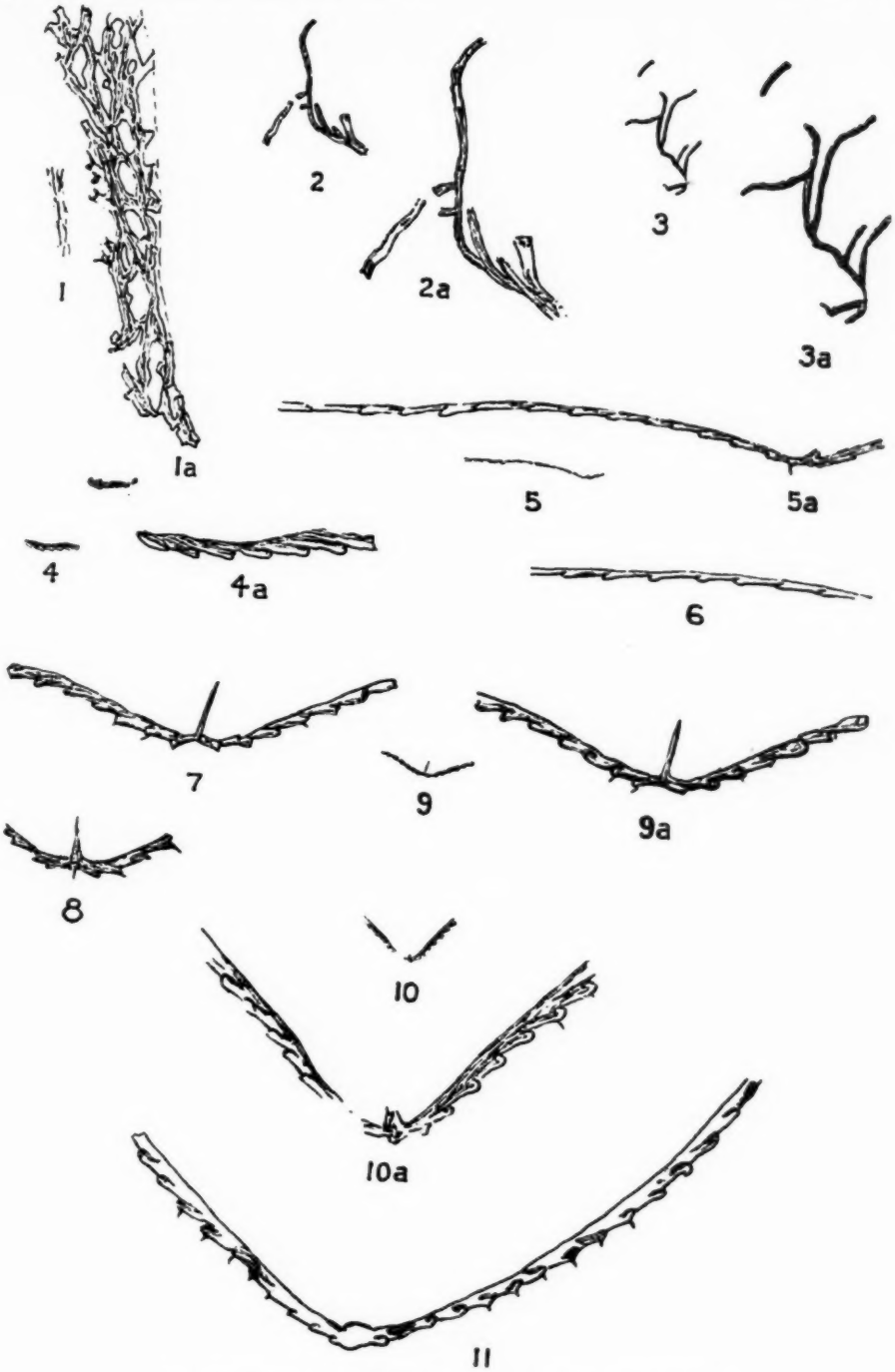
4, 4*a*—*Leptograptus annectans* (Walcott) (×1 and ×4), showing seven long, parallel, almost straight thecae; from east side of U. S. Highway 77, 2½ miles north of Springer, Oklahoma. (p. 305)

5, 5*a*, 6—*Leptograptus flaccidus* Hall var. *macer* Elles and Wood. 5, 5*a*, From near base of Viola at Rock Crossing, Criner Hills, Oklahoma (×1 and ×4). 6, A fragment of left branch of another colony from same locality. (p. 306)

7, 8—*Leptograptus flaccidus* (Hall) mut. *trentonensis* Ruedemann. 7, A small symmetrical colony (×4). The large sicula and fourteen thecae represent a colony only about one-sixth the length of a mature colony. From near base of Viola, Rock Crossing, Criner Hills, Oklahoma. 8, A still smaller fragment of a colony (×4), from P. A. Norris ranch, 1½ miles south of Franks, Oklahoma. (p. 306)

9, 9*a*—*Dicellograptus forchammeri* (Geinitz), a small colony only about one-eighth the length of a mature one (×1 and ×4). While the shape of the rhabdosome is much like that in figure 7, the thecae differ greatly from those of the former in having the apertural portion strongly introverted. From near base of the Viola at Rock Crossing, Criner Hills, Oklahoma. (p. 307)

10, 10*a*, 11—*Dicellograptus forchammeri* var. *flexuosus* Lapworth. 10, 10*a*, Basal part of the large colony (×1 and ×4), from near base of Viola 2 miles west of Nebo, Oklahoma. The entire rhabdosome is 4 inches long with typical pincer-like form. 11, Basal part (×4) of another colony on which apertural spines are well preserved, from the same horizon and locality. (p. 307)



Ruedemann and Decker, Ordovician graptolites

DICELLOGRAPTUS GURLEYI Lapworth

Plate 41, figures 3, 3*a*, 4, 4*a*, 5, 5*a*, 6, 6*a*

Dicellograptus gurleyi LAPWORTH, *1890*, Ms. Rept.; *1896*, Jour. Geology, vol. 4, p. 70.—RUEDEMANN, *1908*, New York State Mus., Mem. 11, p. 303, pl. 19, figs. 7–10.

The branches of the rhabdosome grow to a great length, fragments of 175 to 200 mm. being quite common; they are characteristically twisted and bent in all possible directions, the proximal part forming a small rectangular axil (first angle of divergence 270°) with slightly concave sides, which as a rule is followed by gently convex curves of the branches. The latter grow in loose, opposite turning spirals and therefore frequently describe the figure 8 and bear the thecae alternately on opposite sides of the branches. Branches thin, beginning with a width of 0.5 mm. and soon attaining a uniform width of 0.7 to 0.8 mm., which is maintained in the longest branches. Axil wide, the first two thecae subhorizontal in their direction, provided with short, frequently curved lateral spines. Sicula relatively large (1.6 mm.), frequently free within the axil, with short rigid, rod-like nema and inconspicuous virgella. Thecae nine to twelve in 10 mm., overlapping one-fourth their length; ventral margin of distal free part slightly convex; apertural part slightly introverted; apertural excavation round, occupying about one-third the transverse width of the branch; apertural notch obliquely reflected (Ruedemann).[3]

Dicellograptus gurleyi has thus far been known only from the Normanskill shale of New York. The Upper Ordovician shale of Bruno Creek, Bay Horse quadrangle, Idaho (Kirk coll. 1930), has furnished material from the far west that distinctly belongs in the *gurleyi-caduceus* group of *Dicellograptus*. It has the crossing and twisting branches, forming a figure 8, characteristic of the two species, its branches reach a width of 1 mm., as in *caduceus*, but the thecae number but 10 to 8, thus being a little more widely spaced than in *D. gurleyi*, and closer than in *caduceus* (which numbers 14 to 12 in 10 mm.). The form of the thecae is also in agreement with that of *D. caduceus*. It also occurs in beautiful specimens in the Viola limestone, 1 to 10 feet above the base at Rock Crossing in the Criner

[3] Ruedemann, R., Graptolites of New York, pt. 2: *New York State Mus., Mem* 11, pp. 303–306, pl. 19, figs. 7–10, 1908.

EXPLANATION OF PLATE 41

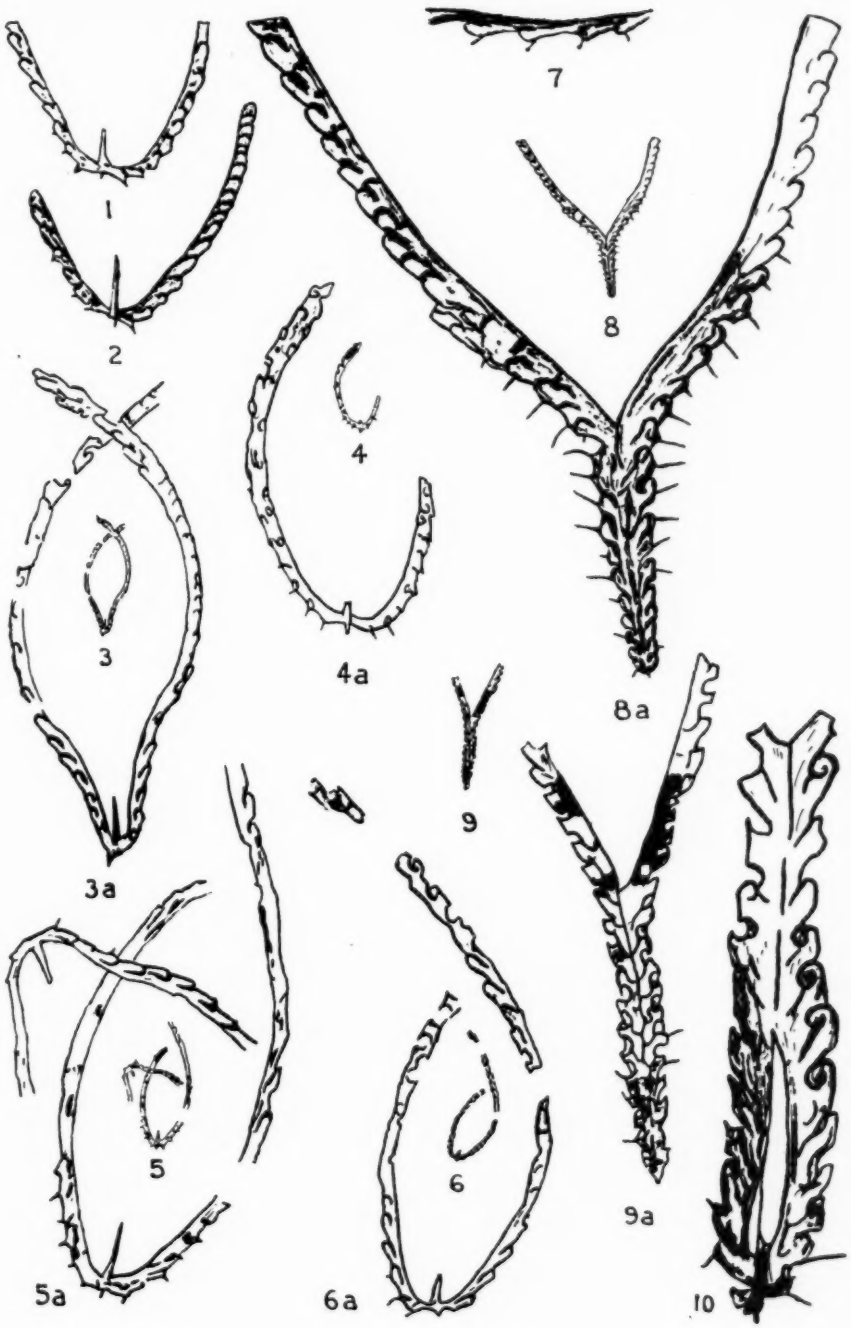
FIGS. 1, 2—*Dicellograptus forchammeri* var. *flexuosus* Lapworth (×4). Young colonies of this size occur in great numbers in some of the beds near the base of the Viola at Rock Crossing, Criner Hills, Oklahoma. (p. 307)

3, 3*a*, 4, 4*a*, 5, 5*a*, 6, 6*a*—*Dicellograptus gurleyi* Lapworth (×1 and ×4), showing the lower part of four different colonies. Complete mature colonies generally have the branches crossing twice in the form of an 8 or they may cross more than twice. From near base of the Viola, Rock Crossing, Criner Hills, Oklahoma. (p. 310)

7—*Dicellograptus sextans* var. *perexilis* Ruedemann, a small fragment of a colony (×4). The colony is generally in the form of a rather floppy wide open V with short thick thecae armed with long slender apertural spines. From zone near base of Viola at Witch Hole, 4 miles southwest of Bromide, Oklahoma. (p. 312)

8, 8*a*—*Dicranograptus nicholsoni* var. *geniculatus* Ruedemann and Decker, n. var., a beautiful colony (×1 and ×4) showing secondary geniculate bend of uniserial branches, and the long slender apertural spines on lower part. From Rock Crossing, Criner Hills, Oklahoma. (p. 312)

9, 9*a*, 10—*Dicranograptus nicholsoni* var. *longibasalis* Ruedemann and Decker, n. var. 9, 9*a*, Lower part of a colony (×1 and ×4) showing eleven thecae on each side of the biserial part of the colony. Common in the basal part of the Viola on P. A. Norris ranch, 2 miles south of Franks, Oklahoma. 10, Very peculiar form (×8) in which six thecae on each side in the basal part remain uniserial and then become joined for the distance of the next five thecae on each side. From P. A. Norris ranch, 2 miles south of Franks, Oklahoma. (p. 313)



Ruedemann and Decker, Ordovician graptolites

Hills (sec. 35, T. 5 S., R. 1 E.). C. E. Decker, collector, 1931.

DICELLOGRAPTUS SEXTANS (Hall) var. PEREXILIS Ruedemann

Plate 41, figure 7

Dicellograptus tenuibranchiatus LAPWORTH, *1887*, Roy. Soc. Can., Trans., vol. 4, p. 179. (Complete synonymy for *D. sextans* with 28 references is given in New York State Mus., Mem. 11, pp. 306–307, 1908.

This species, *D. sextans*, has been described as having:

Branches of rhabdosome diverging at 300°, with acute axil. Straight in shorter specimens and gently curved in longer ones . . . frequently . . . approaching the shape of the handles of a pair of pliers; mostly about 10 mm. long, rarely surpassing 20 mm.; usually of uniform width which is 0.8 mm. Sicular extremity broad, slightly rounded, with short virgella and two lateral spines. Sicula inconspicuous (0.9 mm. long). Nema short and thin. Thecae numbering 11 to 13 in 10 mm., short 1 mm., overlapping one-fourth their length, with obliquely directed, strongly convex outer wall which in its highest mesial part carries a spine; and slightly introverted or introtorted apertural portion, which is inclosed in a semicylindrical excavation occupying one-third the width of the rhabdosome (Ruedemann).[4]

Of *D. sextans* var. *perexilis* Ruedemann it is said:[5]

In a layer of the Normanskill shale at Mt. Moreno *D. sextans* is represented by a variety, the most striking feature of which is the extreme thinness of the branches, the width of the latter amounting to no more than 0.2 mm. Besides the angle of divergence of the branches is constantly smaller (270° in the proximal part and 240° ultimately) and the branches are more flexible. As a result of these characters the habit of the variety is entirely different from the typical *sextans*, but the form and arrangement of the thecae and the presence of the mesial spines on all thecae place it with that species (Ruedemann).

[4] Ruedemann, R., *New York State Mus., Mem.* 11, p. 306, 1908.

[5] Ruedemann, R., *op. cit.*, p. 310.

It is about half the width of the narrow variety *exilis* and has a smaller angle of divergence. Only a small fragment of the *perexilis* variety, consisting of a little more than four thecae, has been found in the Viola limestone, yet these are so characteristic in size, shape and preservation of mesial spines that there is little doubt about the identification. It was found in the most important graptolite zone at the Witch Hole, 4 miles southwest of Bromide at about 50 feet above the base. This zone corresponds with the eroded base of the Viola at Rock Crossing in the Criner Hills and on the P. A. Norris Ranch, 150 feet above base on West Spring Creek, 100 feet on U. S. Highway 77, West Branch of Sycamore Creek, and northeast edge of Bromide. In the Normanskill shale of New York the *perexilis* variety has been found with *Didymograptus sagitticaulis*, *Nemagraptus gracilis*, and *Lasiograptus mucronatus*.

DICRANOGRAPTUS Hall, 1865

DICRANOGRAPTUS NICHOLSONI Hopkinson

Dicranograptus nicholsoni HOPKINSON, *1870*, Geol. Mag., vol. 7, p. 357, pl. 16, fig. 3.—LAPWORTH, *1876*, Cat. West. Scott. Foss., p. 6, pl. 3, fig. 79; *1877*, Belfast Nat. Field Club, Rept. and Proc., Apx., vol. 1, pt. 4, p. 141, pl. 7, fig. 2.—TULLBERG, *1882*, Sver. Geol. Und., ser. C., no. 50, p. 20.—GURLEY, *1896*, Jour. Geology, vol. 4, p. 297.—ROEMER and FRECH, *1897*, Lethaea Pal., vol. 1, p. 617, fig. 181.—HALL, *1905*, Roy. Soc. Victoria, Proc., vol. 18, p. 24, pl. 6, fig. 7.—ELLES and WOOD, *1901–1918*, Monogr. British Graptolites, pt. 4, (Pal. Soc., 1904) p. 171, pl. 25, figs. 1*a–h*.—HALL, *1906*, Geol. Survey Victoria, Rec., vol. 1, pt. 4, p. 274.

DICRANOGRAPTUS NICHOLSONI Hopkinson var. GENICULATUS Ruedemann and Decker, n. var.

Plate 41, figures 8, 8*a*

The biserial part of the rhabdosome of the species *nicholsoni* generally consists of five or six thecae and attains a length of 4 to 6 mm., the uniserial portion may exceed 130 mm. in length. They generally bifurcate in an axillary angle of 40° to 60° and are 1 to 1.2 mm. in width. The thecae generally number ten in 10 mm., but may vary from nine to

thirteen in 10 mm. and they are generally marked with strong mesial spines in the biserial part. The sicula measures 1 to 1.1 mm. in length.

The new variety *geniculatus* differs from the typical *nicholsoni* in that the axillary angle is generally wider, and after diverging, the uniserial branches are flexed inward distinctly in a more or less sharp manner. This new variety has been found at the eroded base of the Viola limestone at Rock Crossing in the Criner Hills and on the P. A. Norris Ranch, 100 feet above the base northeast of Bromide, and 150 feet above on West Spring Creek. A good illustration is shown in the form from Rock Crossing in Plate 41, figures 8, 8*a*.

This new variety occurs much more abundantly in the Stringtown shale at the north edge of the quarry at Stringtown, Oklahoma. Ruedemann has illustrated and described a geniculate type of *Dicranograptus spinifer* from the Normanskill shale at Glenmont, New York. It is interesting that another species of *Dicranograptus*, viz.: *D. nicholsoni*, has produced an exact duplicate of this variety in the Stringtown shale of Oklahoma. A portion of slab shows three specimens of typical *D. nicholsoni*, each with a distinct flexure in the uniserial branches at a like distance as in other species from the bifurcation, so that as far as the uniserial branches are concerned the two varieties are identical. The fact that the geniculations expressed a general tendency in the species in certain areas and not some exceptional variations is indicated by the presence of twice as many more specimens with the same flexure than of other specimens on the same small slab.

DICRANOGRAPTUS NICHOLSONI Hopkinson var. LONGIBASALIS Ruedemann and Decker, n. var.

Plate 41, figures 9, 9*a*, 10

Another new variety of *D. nicholsoni* occurs in great numbers at the base of the Viola limestone in Oklahoma (P. A. Norris ranch, sec. 2, T. 1 N., R. 6 E.; C. E. Decker, collector, 1929). This locality has afforded specimens of *D. nicholsoni*, that while in character and dimensions of the thecae and branches completely show the typical form of the species, possess much longer (10 mm.) biserial portions of the rhabdosome. While these typically have but five thecae on either side, the Oklahoma form has, in both specimens, eleven thecae, thus distinctly varying in one of the characteristic features of the species. Specimens from the Cincinnati region have been seen with as many as eight thecae, thus forming a transitional stage to the present variety which may be distinguished as *longibasalis*.

A peculiar type of this new variety *longibasalis* was found by the junior writer. The peculiarity lies in the fact that an elongate slit occurs in the lower end of the biserial part of the rhabdosome. Here six of the thecae on each side grew in a uniserial fashion, being distinctly separated in the middle line, then the two branches came together and continued joined in the normal manner for the rest of the biserial part. This is an interesting specimen in that it suggests a partial reversion to a former habit of growth. This exceptional form comes from the P. A. Norris ranch and is shown in Plate 41, figure 10.

Suborder B. GRAPTOLOIDEA AXONOPHORA Frech

Family DIPLOGRAPTIDAE Lapworth

DIPLOGRAPTUS McCoy, 1854

DIPLOGRAPTUS (AMPLEXOGRAPTUS) AMPLEXICAULIS (Hall)

Plate 42, figures 1, 1*a*, 2, 2*a*

Graptolithus amplexicaule HALL, *1847*, Pal. New York, vol. 1, p. 79, pl. 26, figs. 11*a–b*; *1869*, New York State Cab. Nat. Hist., 20th Ann. Rept., pl. 3, figs. 6, 7.

Diplograptus amplexicaule EMMONS, *1856*, Am. Geologist, p. 336, pl. 7, figs. 11*a–b*.

Diplograptus amplexicaulis LAPWORTH, *1886*, Roy. Soc. Can., Proc. and Trans., vol. 4, p. 184.—WHITE, *1895*, New York Acad. Sci., Trans., vol. 15, p. 93.—RUEDEMANN,

1901, New York State Mus., Bull. 39, p. 497 ff.

Diplograptus foleaceus mut. *amplexicaule* GURLEY, *1896*, Jour. Geology, vol. 4, p. 298.

Diplograptus (*Glyptograptus*) *amplexicaulis* FRECH, *1897*, Lethaea Pal., vol. 1, p. 632.—RUEDEMANN, *1908*, New York State Mus., Mem. 11, p. 361, pl. 25, figs. 10–13.

Synrhabdosome not observed. Rhabdosomes of moderate dimensions (maximum length 45 mm., maximum width 4 mm.), rapidly attaining the full width (in distance of 10 mm.) which is then maintained; convex on obverse side, and concave on the reverse side, both marked by interlocking thecal walls but without septal sutures. Sicular extremity furnished with short virgella and two minute, straight lateral spines. Sicula small (1.2 mm.) and slender. Thecae tubular with broadly subrectangular section, not growing exactly in the axial plane of the rhabdosome, but curving towards the reverse side (thereby causing the concavity of the rhabdosome) with slightly curving thecal walls (outer margin slightly convex), numbering 13 to 14 in 10 mm., inclined 30–40°, overlapping one-third, apparently without apertural mucros. Nemacaulis not observed (Ruedemann).[6]

Large examples of this species have been found about 150 feet above the base of the Viola limestone, 10 feet above the base of zone 9 at West Spring Creek, sec. 1, T. 2 S., R. 2 W., Oklahoma.

This species occurs in the middle and upper Trenton limestone of New York and in the contemporaneous Snake Hill shale of eastern New York. It is also present in the Maravillas formation of western Texas, where Dr. R. E. King collected it in 1917, 8 miles E. SE. of Point 4361, S. W. Hess, Loc. 286 of Canyon Quadrangle.

Also the variety *pertenuis* (Ruede-

[6] Ruedemann, R., *op. cit.*, p. 362.

EXPLANATION OF PLATE 42

FIGS. 1, 1*a*, 2, 2*a*—*Diplograptus* (*Amplexograptus*) *amplexicaulis* (Hall). 1, 1*a*, A large colony (×1 and ×4) from main graptolite zone about 150 feet above the base of the Viola on West Spring Creek at the west end of the Arbuckle Mountains. 2, 2*a*, Reverse of part of a rhabdosome, from zone 6 near the base of the Viola limestone at the Witch Hole, 4 miles southwest of Bromide, near the east end of the Arbuckle Mountains. (p. 313)

3—*Diplograptus* (*Orthograptus*) *nexus* Ruedemann (×4). From zone 7 about the middle of the Viola on U. S. Highway 77, 2 miles north of Springer. It occurs in this zone in the western, middle, and eastern parts of the mountains. (p. 316)

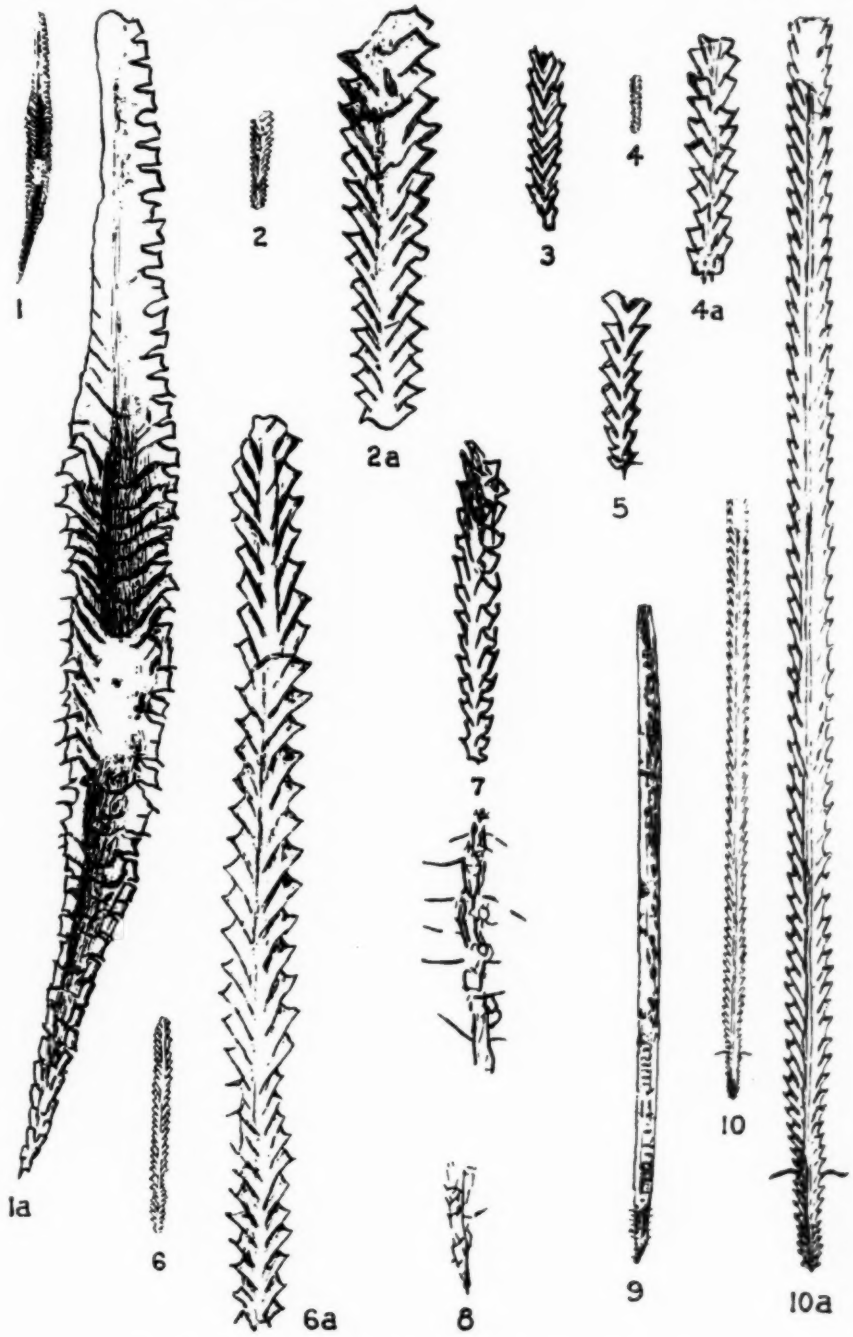
4, 4*a*, 5—*Diplograptus peosta* Hall. 4, 4*a*, A small form (×1 and ×4) occurring in the typical Fernvale phase in zone 1 on U. S. Highway 77, 2 miles north of Springer, Oklahoma. 5, Specimen (×4) from zone 2 near the top of the typical Viola limestone on West Spring Creek at the west end of the Arbuckle Mountains. (p. 316)

6, 6*a*—*Diplograptus* (*Amplexograptus*) *recurrens* Ruedemann (×1 and ×4). From zone 3 near top of the Viola at West Spring Creek. Common in the upper part of the Viola, especially in the western and southwestern parts of the mountains. (p. 316)

7—*Diplograptus vespertinus* Ruedemann (×4). Base of Viola on P. A. Norris ranch 2 miles south of Franks, Oklahoma. It occurs in the lower part of the Viola in the Criner Hills and in all parts of the Arbuckle Mountains. (p. 317)

8—*Glossograptus ciliatus* Emmons. Two fragments of colonies (×4), consisting chiefly of vertical ribs and lateral spines with periderm exfoliated. From base of Viola at Rock Crossing of Criner Hills, Oklahoma. (p. 317)

9, 10, 10*a*—*Glossograptus quadrimucronatus* (Hall) var. *spinigerus* Lapworth. 9, Front view (×1). This large rhabdosome is from near the base of the Viola at Rock Crossing, Criner Hills, Oklahoma, where it is a very common form of large size. 10, 10*a*, Side view of part of a very large rhabdosome (×1 and ×2) showing the abnormally large spines opposite the tenth thecal pair. Rock Crossing, Criner Hills, Oklahoma. (p. 318)



Ruedemann and Decker, Ordovician graptolites

mann, 1908, p. 365), which in New York is very common and characteristic of the Snake Hill shale, occurs in the same horizon in western Texas.

DIPLOGRAPTUS (ORTHOGRAPTUS) NEXUS Ruedemann

Plate 42, figure 3

Diplograptus (Orthograptus) nexus RUEDEMANN, *1925*, New York State Mus., Bull. 262, p. 55, pl. 7, fig. 5.

Rhabdosome strap-shaped, increasing rapidly at proximal extremity to a width of 1.5 mm.; small, attaining a length of 12 mm. or slightly more. Section of rhabdosome flat rectangular. Sicula 0.9 mm. in length. The sicular end is rounded, furnished with a short virgella on the sicula and two lateral spines on the first theca. Thecae 13 to 15 in 10 mm. having a length of 2 mm., very straight, of semicircular section, widening somewhat abruptly at the edge of the aperture, overlapping one-half of the total length, inclined at an angle of 30–40°, four times as long as wide. A septum is present, apparently not developed until about six thecae have grown on each side (Ruedemann).

D. nexus has been found at three localities in the Arbuckle Mountains of Oklahoma in about the middle of the Viola limestone, in zone 7 along U. S. Highway 77, in zones 7 and 8 on the West Branch of Sycamore Creek and in zone 4 northeast of Bromide.

It occurs in the Whetstone Gulf (Eden) beds at Wood Creek, Lees Center, near Rome, New York, and in the Lorraine Gulf, also in the Sheguiandah shale (middle Eden), western Ontario, and in the basal Eden at Fields, Ontario.

DIPLOGRAPTUS PEOSTA Hall

Plate 42, figures 4, 4*a*, 5

Graptolithus (Diplograptus) peosta HALL, *1861*, Supt. Geol. Survey Wis. Rept., p. 17.
Diplograptus peosta HALL, *1862*, Geol. Wis., vol. 1, p. 430.—GURLEY, *1896*, Jour. Geology, vol. 4, p. 298.—WHITFIELD, *1895*, Am. Mus. Nat. Hist., Mem. 2, p. 47, pl. 5, fig. 12.—RUEDEMANN, *1908*, New York State Mus., Mem. 11, p. 372, pl. 25, fig. 17, and text fig. 319.

The rhabdosomes are throughout of small size; length 14 to 20.5 mm., width at sicula 1.4 mm., increases gradually to 2 or 2.6 mm., so that it appears nearly uniform in width. The section of the rhabdosome is oval with both sides convex. The thecae number 11 to 13 in 10 mm., are inclined at an angle of 30° to 40°, imbricated on median line, overlapping two-thirds their length, four times as long as wide.

This species occurs in the Fernvale phase of the Viola along U. S. Highway 77 and just below the Fernvale in the top of the typical Viola on West Spring Creek.

It occurs in the Maquoketa shale of Iowa, Wisconsin and Minnesota.

DIPLOGRAPTUS (AMPLEXOGRAPTUS) RECURRENS Ruedemann

Plate 42, figures 6, 6*a*

Diplograptus recurrens RUEDEMANN, *1925*, New York State Mus., Bull. 262, p. 58, pl. 7, figs. 2–4, text figs. 42–46.

Diplograptus recurrens can be distinguished from *D. nexus* where preserved in relief by its plano-convex to concavo-convex section, and when flattened out by the greater length and very gradual widening of the rhabdosome. It may be described as follows:

Rhabdosome narrow lanceolate about 20–23 mm. long, gradually attaining a width of 1.8 mm. from a proximal width of 1 mm.; concavo-convex or plano-convex in section. Sicula not observed, but a stout, short virgella has been noted. Thecae semicircular in section, long and straight, numbering 13 to 16 in 10 mm.; 2.5 mm. long, and overlapping one-half of their length, inclined at an angle of 40°. Apertural margin straight and perpendicular to axis of theca. No septum observed (Ruedemann).

This is one of the most abundant species in the upper part of the Viola limestone in the southern and western part of the Arbuckle Mountains. It occurs in zones 2 to 5 on West Spring Creek, 3 to 6 on U. S. Highway 77, and zone 7 on the West Branch of Sycamore Creek. Also, it occurs in the lower Lorraine (Whetstone Gulf formation).

The Arnheim beds of the Richmond formation near Oxford, Ohio (no. 1, 1L of Schideler collection), have furnished specimens of *Diplograptus recurrens* that differ in the dimensions, the rhabdosomes being longer (35 mm. long) and wider (2 to 3 mm.), while the section is the same (plano-convex to concavo-convex) and the thecae are alike, numbering 16 to 13 in the space of 10 mm. In its dimensions this mutation returns to the Trenton ancestor *Diplograptus* (*Amplexograptus*) *amplexicaulis* (Hall). It (this Ohio form) may be known as the mut. *richmondensis*.

Diplograptus vespertinus Ruedemann

Plate 42, figure 7

Diplograptus pristis (parte) Hall, *1847*, Pal. New York, vol. 1, pl. 72, figs. 1, 1*a–b–k–l*.
Diplograptus foliaceus mut. *vespertinus* Ruedemann, *1908*, New York State Mus., Mem. 11, p. 352, pl. 25, figs. 4, 5.

Synrhabdosome not observed. Rhabdosomes as a rule short, about 15 mm. with greatest length 42 mm., widening gradually from an initial width of 1 mm. to a maximum width of 2.5 mm. which is attained in a distance of 15 mm. and then maintained. Sicula not observed. Sicular extremity furnished with a short blunt virgella (about 0.4 mm. long) and two equally short straight lateral spines. Thecae number 11 to 13 in 10 mm., inclined at an angle of 30 to 40°, overlapping a little more than one-third, the outer margin distinctly convex with the proximal part frequently slightly concave (Ruedemann).

This is one of the most common of the species that occur in the most marked graptolite zone near or at the base of the Viola limestone. It occurs in zones 8 and 9 on West Spring Creek, 10 on U. S. Highway 77, 13 West Branch of Sycamore Creek, 6 at Witch Hole, 4 on northeast edge of Bromide, 11 P. A. Norris ranch, and near base at Rock Crossing in Criner Hills. It occurs in the Snake Hill beds at Van Schaick Island, north of Albany, New York.

Glossograptus Emmons, 1856

Glossograptus ciliatus Emmons

Plate 42, figure 8

Glossograptus ciliatus Emmons, *1855*, Am. Geology, vol. 1, p. 103, pl. 1, fig. 25.—Ruedemann, *1908*, Graptolites of New York, pt. 2, p. 379, pl. 26, figs. 1–5, pl. 27, figs. 1–4. (A synonymy of 17 references is given by Ruedemann pp. 379–380.)—Elles and Wood, *1901–1918*, British Graptolites, p. 309, pl. 33, fig. 1.

Synrhabdosome not observed. Rhabdosome prismatic with subhexagonal section, attaining a length of 25 plus mm. and a width of 1.6 mm. on the frontal sides and the double width on the lateral faces (often double that width again in obliquely compressed specimens). Sicular extremity rounded, furnished with four short straight sicular spines (1.2 mm. long) which are directed downward, and two longer horizontal lateral spines. Lateral faces smooth bearing along the median line a row of straight spines (1.4 mm. long) which are directed upward at an angle of 40° and correspond to every second theca. Sicula large (3.3 mm.) plump, with four apertural spines that are connected by a strong apertural ring. Thecae broad and low (ratio 2:1), rectangular in section, inclined at an angle of 30°, overlapping three-fourths their length, numbering 11 in 10 mm. with little variation. Apertures rectangular, lower and upper margins straight, lateral margins concave, each protected by two long curved spines. . . Nemacaulus thin (0.1 mm.) attaining great length (30 mm.) and frequently inflated into a fusiform vesicle (Ruedemann).[7]

Several forms of this species have been found near the base of the Viola limestone at Rock Crossing, Criner Hills, Oklahoma, and in zone 9 on West Spring Creek.

This species is also well represented in the shale at Fall Creek, Hailey quadrangle, Idaho (U. S. Geol. Survey, Coll. 1370), where it is associated with a typical Normanskill fauna.

Large and well-preserved specimens referable to this species occur in the upper Glenogle shale in association with

[7] Ruedemann, R., *op. cit.*, p. 380.

Normanskill shale forms. The figured specimen is from the Glenogle slate quarries (Canada Geol. Survey, Loc. 353, Ami Coll.). The specimens obtained there are much larger than in the homotaxial beds in New York, individuals of a length of 3 cm. having been observed.

GLOSSOGRAPTUS QUADRIMUCRONATUS (Hall)

In his synonymy of this species Ruedemann[8] gives 28 references. His description is as follows:

Entire colony forming a synrhabdosome which is composed of 30 or more sicula-bearing rhabdosomes. The latter stout and long, quadrilateral, the lateral and frontal sides of approximately equal width; the lateral faces plain, the frontal ones straight or very gradually increasing in width to 3 mm.; attaining a length of 60 mm. and more in the largest fragments. Periderm consisting of a thick outer layer and a fibrous inner one. Sicula stout, nearly 2 mm. long, provided with a straight apertural margin and a distinct virgella. Thecae relatively broad and short, three times as long as wide, overlapping two-thirds their length; forming an angle of 30°–32° with the axis, numbering 11 in the space of 10 mm. at the sicular end and 10 at the antisicular end in the typical form. Each apertural angle produced into a mucronate spine which equals in length the width of the aperture and is rectangular on the axis of the theca (Ruedemann).

No separate figure of this species is shown. It is much like the variety *spinigerus* shown in Plate 42, figures 10, 10*a*, though smaller with thecae more crowded and lacking the long spines near the sicular end.

This species occurs widespread in the Viola limestone from the base to near the middle of the formation. It is common in the Utica shale of New York and Canada, in the *Pleurograptus-linearis* zone in Scotland, and in the *Trinucleus* beds in Scandinavia. *Trinucleus* (*Cryptolithus*) is also associated with it in abundance in the Viola limestone.

[8] Ruedemann, R., Graptolites of New York, part 2, pp. 385–386.

GLOSSOGRAPTUS QUADRIMUCRONATUS (Hall) var. SPINIGERUS Lapworth

Plate 42, figures 9, 10, 10*a*

Diplograptus quadrimucronatus var. *spinigerus* LAPWORTH, *1876*, Cat. West Scott. Foss., pl. 2, fig. 43.

Diplograptus (*Orthograptus*) *quadrimucronatus* var. *spinigerus* ELLES and WOOD, *1901–1918*, British Graptolites, p. 225, pl. 28, figs. 2*a–d*.

In addition to the typical form already described there occurs a second form of *Orthograptus quadrimucronatus*, which appears to be sufficiently distinct to be classed as a variety. It occurs on the same horizon as *O. quadrimucronatus*, but is usually larger, and has abnormally developed spines on the thecae about 8 mm. from the proximal end, this position corresponding apparently with the tenth thecal pair. These thecae are each furnished typically with a pair of long curved spines having a length of 5 mm. or more, and which are remarkably conspicuous in compressed specimens. Occasionally also spines of corresponding abnormal length are developed on the thecae lying immediately below (ninth pair) and also on the fourteenth pair (pl. 28, 2*b*) but as a rule they are confined to the tenth pair alone. In this variety, also, the thecae usually number 10–8 in 10 mm, but occasionally, as in those from Mount Benger Burn, the thecae are a little more closely set (Elles and Wood).

This variety, *spinigerus*, is widespread in the Arbuckle Mountains of Oklahoma and it occurs in great numbers in the lower part of the Viola limestone at West Spring Creek West Branch of Sycamore Creek, and at Rock Crossing in the Criner Hills. It occurs also 2 miles west of Nebo, at the Witch Hole southwest of Bromide, and at the northeast edge of Bromide.

The Viola limestone of Oklahoma contains this large variety of *Glossograptus quadrimucronatus* that is characterized by exceptionally long pairs of apertural spines on the tenth pair of thecae. It has this character as well as its great size

(82 mm. in common with the British variety *spinigerus* Lapworth. See British Graptolites, p. 225) and may well be identified with the same, although the latter develops still greater size and width.

The occurrence of this British form is the more unexpected in Oklahoma, since New York has already furnished a similar form, but clearly distinct from the British variety by having the longer spines opposite the fifth to seventh pairs of thecae, hence closer to the sicula. This is the variety *inequispinosus* (Ruedemann, 1925, p. 66) occurring in the upper Utica shale at Holland Patent, New York; however, specimens of *spinigerus* were also observed (idem, p. 67) at another locality and probably a lower horizon of the Utica shale of New York. It occurs in the *Pleurograptus linearis* zone of the Hartfell shales of southern Scotland.

CLIMACOGRAPTUS Hall, 1865

CLIMACOGRAPTUS CAUDATUS Lapworth

Plate 43, figures 1, 1*a*

Climacograptus caudatus LAPWORTH, *1876*, Cat. West. Scott. Foss., p. 6, pl. 2, fig. 48.

Climacograptus scalaris var. *caudatus* LAPWORTH, *1877*, Grapt. Co. Down, p. 138, pl. 4, fig. 34.

Climacograptus caudatus ELLES and WOOD, *1901–1918*, British Graptolites, p. 202, text fig. 133, pl. 27, figs. *7a–c.*—RUEDEMANN, *1908*, New York State Mus., Mem. 11, p. 438, text fig. 406, pl. 28, figs. 17, 18. (In this last reference Ruedemann gives a list of eight additional references in his synonymy).

Polypary 2–6 cm. or more in length exclusive of the virgellar prolongation, widening gradually from its proximal end to a maximum breadth of about 2–2.5 mm., which is then maintained to the distal extremity. Sicula obscure, virgella 1–3 cm. or more in length; virgula considerably prolonged. Thecae 12–9 in 10 mm., free outer edge curved, slightly inclined. Apertural margin horizontal or introverted; situated in excavations occupying one-fourth the width of the stipe and one-third of its ventral margin.

In the distal region of the polypary the margins are parallel, but proximally they vary markedly, the maximum width being attained at a distance of about 2.5 cm. from the proximal end. The proximal prolongation of the virgella is very striking and characteristic, being 1–3 cm. or more in length; close to the polypary it is frequently surrounded by a membranous body with a length of 3 mm. to 1.3 cm., this is clearly not a part of the true polypary, though it sometimes appears like a prolongation of it; probably the whole sicula was once surrounded by a membrane as in *C. wilsoni*. The sicula does not appear to be free in either side for any part of its length.

The septum seems to be complete throughout the entire extent of the polypary. The free outer edges of the distal thecae in this species are distinctly inclined, and point in the direction of those of *Diplograptus* (Elles and Wood).[9]

We have before us now finely preserved specimens from the base of the Viola limestone (zone 12, 10 feet above base) at West Spring Creek, east of Pooleville, Oklahoma, sec. 1, T. 2 S., R. 2 W. (C. E. Decker collector, 1931). It occurs also near the base of the Viola on the east side of U. S. Highway 77, 2½ miles north of Springer.

Climacograptus caudatus is widely spread in Europe (Great Britain and Scandinavia). It is there one of the characteristic graptolites of the zone of *Dicranograptus clingani* which lies between our lower Normanskill and the Utica shale. It has been described by the writer from the Snake Hill shale of Trenton age at Mechanicville, New York. It also occurs in the Magog shale at Magog, Quebec, appearing there in shale of the age of the upper Normanskill shale.

It occurs at eight different localities in the Hartfell shales in Scotland and also in Ireland.

CLIMACOGRAPTUS EXIMIUS Ruedemann

Plate 43, figures 2, 2*a*

Cf. *Diplograptus putillus* LAPWORTH, *1886*, Roy. Soc. Can., Proc. and Trans., vol. 4, p. 170, 178 ff.

[9] Elles and Wood, *op. cit.*, pp. 202–3.

Diplograptus aff. *putillus* RUEDEMANN, *1901*, New York State Mus., Bull. 42, p. 541.
Climacograptus putillus (Hall) mut. *eximius* RUEDEMANN, *1908*, New York State Mus., Mem. 11, p. 420.

Climacograptus eximius is a very small form having an average length of 8 mm. and a width of 0.7–1 mm. and the thecae are short and arranged 16–18 in 10 mm. While most of the specimens possess only a short virgella at the sicular extremity, a few are distinctly furnished with short lateral spines.

While relatively rare, this species occurs at three localities in the Viola limestone in the Arbuckle Mountains, at West Spring Creek, on U. S. Highway 77, and on the West Branch of Sycamore Creek. In all three places it was found near the base and in the first two it ranged up toward the middle of the formation.

Specimens showing a like character of the thecae and equal dimensions occur in the Stringtown shale at Stringtown, Atoka County, Oklahoma. In New York it occurs in the Normanskill shale near Glenmont, Albany County, but especially at Lansingburg it occurs in great numbers associated with Normanskill forms.

EXPLANATION OF PLATE 43

FIGS. 1, 1*a*—*Climacograptus caudatus* Lapworth, beautifully clear cut specimens (×1 and ×4). From 10 feet above the base of the Viola on West Spring Creek, and it occurs in a similar zone on U. S. Highway 77. It should be found on the West Branch of Sycamore Creek, but not in the east end of the mountains nor at Rock Crossing in the Criner Hills, as in the last two localities the oldest part of the Viola is wanting because of erosion. (p. 319)

2, 2*a*—*Climacograptus eximius* Ruedemann (×1 and ×4), from zone 9 about 150 feet above the base of the Viola on West Spring Creek. The species extends to east end of the mountains. (p. 319)

3, 4—*Climacograptus lorrainensis* Ruedemann (×4). 3, Specimen from zone 3 in upper part of Viola on U. S. Highway 77, 2 miles north of Springer, Oklahoma; found also in zone 2, West Spring Creek. 4, Specimen from zone 2, 5 miles north of Bromide, Oklahoma. It occurs, therefore, at both ends of the mountains, as well as on U. S. Highway 77. (p. 322)

5, 5*a*—*Climacograptus spinifer* Ruedemann. Part of a colony (×1 and ×4) showing one of the two long slender spines characteristically occurring at the base of the colony, from zone 11 at base of Viola on P. A. Norris ranch. This species occurs also at the Witch Hole 4 miles west of Bromide, and at Rock Crossing in the Criner Hills. (p. 322)

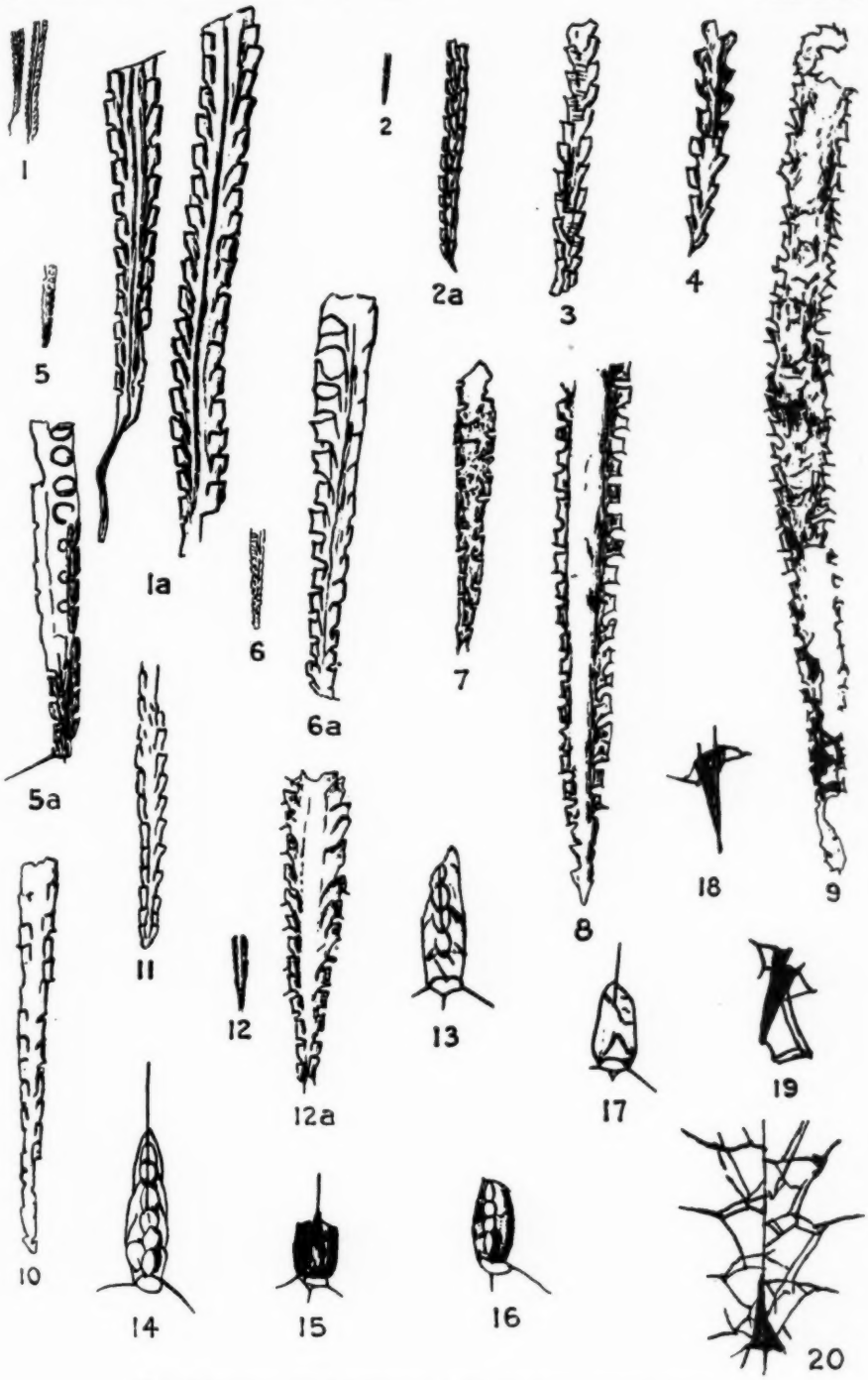
6, 6*a*, 7—*Climacograptus typicalis* Hall. 6, 6*a*, Basal part of a colony (×1 and ×4), from base of Viola, P. A. Norris ranch. 7, Basal part of another colony (×4), from zone 11, West Branch of Sycamore Creek. Abundant in the main lower graptolite zone throughout the mountains and especially at Rock Crossing in the Criner Hills. (p. 322)

8, 9, 12, 12*a*—*Climacograptus typicalis crassimarginalis* Ruedemann and Decker, n. var. 8, A broad swollen form (×4). 9, Another specimen (×4). 12, 12*a*, Part of another colony (×1 and ×4). All figured specimens from zone 6, near base of the Viola at Witch Hole, 4 miles southwest of Bromide. Found also on West Branch of Sycamore Creek and at the west end of the mountains on West Spring Creek. (p. 322)

10, 11—*Climacograptus typicalis* mut. *posterus* Ruedemann (×4). Both of these small narrow forms are from zone 2, near the top of the Viola, 5 miles north of Bromide. (p. 323)

13–17—*Cryptograptus insectiformis* Ruedemann, five small colonies (×4). Figures 13, 14, and 16 are from 2 miles west of Nebo; 15 from Rock Crossing in the Criner Hills; and 17 from West Spring Creek. It has also been found in the east-central part of the mountains near the town of Mill Creek. (p. 324)

18–20—*Lasiograptus* (*Thysanograptus*) *eucharis* (Hall), two initial thecae and a larger colony (×4). From Rock Crossing in the Criner Hills. The species occurs in the western, central, and eastern parts of the mountains.. (p. 324)



Ruedemann and Decker, Ordovician graptolites

UNIV. OF MICH.

CLIMACOGRAPTUS LORRAINENSIS Ruedemann
Plate 43, figures 3, 4

Climacograptus lorrainensis RUEDEMANN, *1925*, New York State Mus., Bull. 262, p. 63, text figures 49–52 (on p. 61), pl. 7, figs. 11–13.

This is a late dwarfed form with the thecae of *Climacograptus typicalis* but much smaller (average 7–9 mm. long), 1 mm. wide and having 12 to 14 thecae in 10 mm. In New York it appears rather abruptly in the middle Lorraine. In Oklahoma it occurs near the top of the Viola limestone (zone 3, sec. 25, T. 2 S., R. 1 E.) near U. S. Highway 77; zone 2 on West Spring Creek and zone 2, 5 miles north of Bromide. C. E. Decker, collector, 1931.

CLIMACOGRAPTUS SPINIFER Ruedemann
Plate 43, figures 5, 5*a*

Climacograptus typicalis Hall mut. *Spinifer*, RUEDEMANN, *1908*, New York State Mus., Mem. 11, p. 411, text fig. 363, pl. 28, figs. 8, 9.

In comparison with *C. typicalis* this new species of Ruedemann's from Saratoga County, New York, is much narrower (1.2 to 1.8 in width) and the thecae are closer arranged having 14 in 10 mm. in the mature part. But the most conspicuous difference from *C. typicalis* is the presence of two straight, thin spines reminding one of the sicular spines of *C. bicornis*. These two spines from their angle of growth are quite clearly further prolongations of the sicular spines, hence not homologous at all to the two lateral spines of *C. bicornis*, which grow from the first two thecae.

C. spinifer is a common form at the base of the Viola limestone on the P. A. Norris ranch, 2 miles south of Franks, Oklahoma, and it occurs at the Witch Hole 4 miles southwest of Bromide, and at Rock Crossing in the Criner Hills.

CLIMACOGRAPTUS TYPICALIS Hall
Plate 43, figures 6, 6*a*, 7

Climacograptus typicalis HALL, *1865*, Can, Org. Rem. Dec. 2, pp. 27, 28, 57, pl. A. figs. 1–9.—RUEDEMANN, *1908*, New York State Mus., Mem. 11, pp. 407–411, text figs. 354–362, pl. 28, figs. 6, 7; *1925*, New York State Mus., Bull. 262, p. 59. (In his synonymy Ruedemann gives ten additional references to this species.)

Synrhabdosome not observed. Rhabdosome long (66 mm. plus), narrow with extremely narrow whip-shaped sicular end (0.3–0.4 mm.) which in the space of 16 mm. attains the mature width of 2–2.4 mm., which is then maintained. Lateral sides convex, smooth, broad. . . . Sicula short (1.2 mm.) its aperture possessing two short mucros. Thecae closely arranged (11 to 15 in 10 mm.), overlapping one-third in mature part, one-fourth and less in sicular end; twice bent. . . . Aperture horizontal to slightly everted, apertural excavations short and deep (Ruedemann).[10]

C. typicalis is widespread and abundant in the Viola limestone, occurring in nearly every outcrop where the lower part of the formation is exposed. It is most abundant in the main graptolite zone which occurs near the base, but generally ranges up about one-third the distance toward the top. Other species of *Climacograptus* occur near the top as well as several *Diplograptids* which may have been inadvertently classed with this very common form. It is the most abundant fossil in the Utica shale of New York particularly in the lower part, but it ranges up through the formation, and it has been found in the Galena formation of Minnesota.

CLIMACOGRAPTUS TYPICALIS CRASSIMARGINALIS
Ruedemann and Decker, n. var.
Plate 43, figures 8, 9, 12, 12*a*

The Viola limestone, northwest of Bromide Spring, has, 60 feet above the base, furnished a variety of *Climacograptus typicalis* which shows only minute mesial spines in the majority of the specimens. Some, however, like the one here figured, show that the mesial mucro is in reality a sharp projecting edge or flange. It is probable that this flange becomes later on reduced to the mesial

[10] Ruedemann, R., *New York State Mus., Mem.* 11, p. 407.

spine one sees in the higher Viola beds and in *innotatus* Nicholson of the Birkhill shales.

The mesial mucros of *Climacograptus* in the upper beds were recognized by Ruedemann in the graptolites of New York (p. 409), but he had about decided that this mutation was a late development until they were found to occur commonly in the lower part of the Viola limestone.

This new evidence that these spines occurred early in the history of the genus and the species may be suggestive of the possibility that they were marginal spines on the edge of the aperture and that the typical second flexure of *Climacograptus* and subsequent lengthening of the thecae were added to a former early *Diplograptus* type.

Doctor Ruedemann's manuscript discussion on these spines follows:

A slab of limestone from the shore (between the Grindstones) of Lake Winnipeg, Man., collected and sent to me for inspection by Miss Alice E. Wilson, contains a beautifully preserved *Climacograptus* distinctly of the type of *typicalis* Hall, but distinguished as a mutation by the smaller dimensions, closer arrangement of the thecae (14 in 10 mm.), and especially by the presence of short spines on the thecae. The latter are, however, not placed at the apertural margin, but in the middle of the free edge where it bends into the straight, vertical portion of the thecae. There is at present known but one species of *Climacograptus* having such spines, viz., *C. innotatus* Nicholson of the British Birkhill shales. This species, which recently has been observed in collections of the uppermost Ordovician of Idaho, is readily distinguished from the form before us by the entirely different outlines of rhabdosome and the shorter thecae.

The senior writer has already mentioned in Memoir 11 (p. 409) that "The geniculated part of the thecal wall" of *C. typicalis* in some specimens is produced into a mucro, and has observed this feature repeatedly in post-Utica mutations of *C. typicalis* mut. *posterus* Ruedemann, described by the writer from the post-Utica Deer River and Atwater Creek shale of New York. It seems certain from the character of the mutation that it is of post-Utica and possibly Lorraine or even later age. On account of its different character, it deserves recognition by a separate name (Ruedemann).

C. typicalis with mesial spines occur commonly in the lower part of the Viola limestone on West Spring Creek, on U. S. Highway 77, West Branch of Sycamore Creek, and Rock Crossing, Criner Hills, as well as in the eastern end of the mountains at the Witch Hole, from which locality the specimen illustrated in Plate 43, figures 12, 12*a* was collected. Since this variety was described by us in manuscript, a similar form has been described by Ian Cox[11] from Ordovician limestone of Akpatok Island in Ungava Bay, North Canada. *C. inuiti* is distinguished by prominent flanges on the mesial angle, such as our form has. It differs, however, in the general outline of the rhabdosome.

CLIMACOGRAPTUS TYPICALIS Hall mut. POSTERUS Ruedemann

Plate 43, figures 10, 11

Climacograptus typicalis Hall mut. *posterus* RUEDEMANN, *1925*, New York State Mus., Bull. 262, pp. 60–61, text figures 47, 48, pl. 7, fig. 14.

The mutation *posterus* of *C. typicalis* was described by the senior writer from the last stages of black shale deposition of Utica and Frankfort age in the Black River valley (Deer River and Atwater Creek shale).

It is distinguished from the type of the species by its smaller size (13 to 15 mm. average length), the more uniform and more rapid widening (within 8 mm.) to a width of but 2 mm. (in most specimens only 1.5 mm.); the closer arrangement of the thecae (12 to 15 in 10 mm.) and the thinner test of the rhabdosomes.

Specimens with the characters of this mutation have also turned up in zone 2

[11] Cox, Ian, On *Climacograptus inuiti* sp. nov. and its development: *Geol. Mag.*, vol. 70, no. 823, pp. 1–19, 1933.

of the Viola limestone of Oklahoma, 5 miles north of Bromide (sec. 17, T. 1 S., R. 8 E.) indicating Utica-Lorraine age for the upper Viola.

CRYPTOGRAPTUS Lapworth, 1880

CRYPTOGRAPTUS INSECTIFORMIS Ruedemann

Plate 43, figures 13–17

Cryptograptus tricornis mut. *insectiformis* RUEDEMANN, *1908*, Graptolites of New York, pt. 2, New York State Mus., Mem. 11, p. 448, pl. 28, fig. 5.

A smaller variety of this characteristic graptolite was recognized in a collection made by Prof. Charles E. Decker near base of Viola limestone, 2 miles northeast of Crusher or 2 miles west of Nebo store, Oklahoma. (NE. cor. sec. 27., T. 2 S., R. 3 E.) This species occurs also in the main lower graptolite zone on West Spring Creek, the West Branch of Sycamore Creek, at Rock Crossing in the Criner Hills, and near the town of Mill Creek.

The specimens agree fully in outline with the New York material, but are smaller (5 mm. long) and have the thecae closely arranged (14 to 16 in 10 mm.).

Ruedemann's original description of this new species is:

> The rhabdosome is short (8–9 mm. long), rounded and broadest at the sicular end (1.6 mm.) and somewhat abruptly contracted to 1.2 mm., after the first third of this length. The thecae are very closely arranged (16 in 10 mm.), the sicular spines strongly curved.[12]

Family RETIOLITIDAE Lapworth

LASIOGRAPTUS Lapworth, 1873

LASIOGRAPTUS (THYSANOGRAPTUS) EUCHARIS (Hall)

Plate 43, figures 18–20

Retiograptus eucharis HALL, *1865*, Canada Geol. Survey, Org. Rem., Decade 2, p. 146, pl. 14, fig. 9; *1868*, New York State Cab. Nat. Hist., 20th. Ann. Rept., pp. 206, 224, pl. 4, fig. 9.—WALCOTT, *1881*, Albany Inst., Trans., vol. 10 (Advance Sheet *1870*, p. 35).—AMI, *1889*, Canada Geol. Survey, Ann. Rept., pt. 2, (for 1887–1888), pp. 23 K, 117 K.

[12] Ruedemann, R., *op. cit.*, p. 448.

Retiolites? eucharis AMI, *1893*, Canada Rec. Sci., vol. 5, pp. 180, 236.

Diplograptus pristiniformis RUEDEMANN, *1895*, Am. Jour. Sci., vol. 18, pp. 453, 455, figs. 2, 3.—WIMAN, *1895*, Geol. Inst. Upsala, Bull., vol. 2, pt. 2, pp. 69, 71, figs. 2, 3.

Diplograptus ruedemanni GURLEY, *1896*, Jour. Geology, vol. 4, pp. 298, 307.—RUEDEMANN, 1895, New York State Geol., 48th Ann. Rept., p. 221, pl. 5.—TORNQUIST, *1897*, Zool. Centrabl., vol. 4, p. 5

Diplograptus cf. *aculeatus* Frech, ROMER and FRECH, *1897*, Leathea Pal., vol. 1, p. 633, pl. A, fig. 2.

Diplograptus ruedemanni et *spinulosus* (nom. nud.) RUEDEMANN, *1901*, New York State Mus., Bull. 42, p. 523 ff.

Glossograptus eucharis RUEDEMANN, *1908*, New York State Mus., Mem. 11, pp. 397–400, text figs. 346–352, pl. 26, figs. 18, 19, pl. 27, figs. 11–13.

Hall's original description is as follows:

> Frond spreading, nearly flat, consisting of numerous narrow lanceolate elliptical stipes attached to a common initial point or axis, and bilaterally arranged on two sides of a short funicle, which is four or five times bifurcated on each side. Stipes varying in proportion, the length being from three to five times the width; axis very distinct, undulating, and its continuation traced from the radicle to the distal extremity, beyond which it extends in a mucronate point. Cell partitions distinct, alternating, essentially rectangular to the axis, the cellules having their greatest development about the middle of the length of the stipe. Margins of the stipe ornamented by short mucronate points which alternate with the cell-partitions.

Lasiograptus eucharis was originally described from the Utica shale (Gloucester shale) of the Lake St. John region in Labrador. The senior writer has found it to range through the Canajoharie and Snake Hills shales which are of Trenton age and beyond the Utica into the Frankfort shale of Lorraine age.

Also the horizontal distribution of this small and interesting graptolite is undoubtedly much greater than hitherto suspected. This is indicated by its appearance in the Viola limestone of Okla-

TABLE I.—*List of Graptolites by Zones*

Localities	1	2	3	4	5	6	7	8	9	10
Climacograptus caudatus Lapworth	12	11								
Climacograptus eximius Ruedemann	7, 8, 12	8, 11	13, 11		6					
Climacograptus lorrainensis Ruedemann	2	3					2			
Climacograptus spinifer Ruedemann					6				11	b
Climacograptus typicalis Hall	8, 9	7, 8, 10, 11	12, 13, 14	b	6		4		11	b
Climacograptus typicalis crassimarginalis Ruedemann and Decker, n. var.	12	11	12, 13, 14	b	6		4		11	b
Climacograptus typicalis posterus Ruedemann		3						2		
Cryptograptus insectiformis Ruedemann	9		13	b						b
Desmograptus oklahomensis Ruedemann and Decker, n. sp.					6					
Dicellograptus forchammeri (Geinitz)										b
Dicellograptus forchammeri flexuosus Lapworth			13	b	6					b
Dicellograptus gurleyi Lapworth		10								
		10								b
Dicellograptus sextans var. *perexilis* Ruedemann					6					
Dicranograptus nicholsoni geniculatus Ruedeman and Decker, n. var.	9			b			4		11	b
Dicranograptus nicholsoni longibasalis Ruedemann and Decker, n. var.									11	b
Diplograptus (*Amplexograptus*) *amplexicaulis* Hall	9									b
Diplograptus nexus Ruedemann		7	7, 8				4			
Diplograptus peosta Hall	2	1								
Diplograptus recurrens Ruedemann	2, 3, 4, 5	3, 5, 6	7							
Diplograptus vespertinus Ruedemann	8, 9	10	13		6		4		11	
Glossograptus ciliatus Emmons	9									b
Glossograptus quadrimucronatus (Hall)	7, 9, 12	6, 10	8, 11, 13		6		4			b
Glossograptus quadrimucronatus spinigerus Lapworth	7, 9	7, 13, 14		b	6		4			b
Lasiograptus (*Thysanograptus*) *eucharis* Ruedemann	4	10	13	b	6				11	b
Leptograptus annectans (Walcott)		10								
Leptograptus capillaris Caruthers		10								
Leptograptus flaccidus macer Elles and Wood	9	10	13	b	6		5			b
Leptograptus flaccidus trentonensis Ruedemann				b	6				11	
Mastigograptus circinalis Ruedemann										b
Mastigograptus cf. *gracillimus* Lesquereux					6				11	b

The number of zones in each of the above sections varies greatly as given below:

1. West Spring Creek, 12 zones.
2. U. S. Highway 77, 11 zones.
3. West Branch Sycamore Creek, 14.
4. Two miles west of Nebo, base.
5. Witch Hole, 6 zones.
6. West edge of Bromide, middle and lower.
7. Northeast edge of Bromide, 9.
8. Five miles north of Bromide, 5 zones.
9. P. A. Norris Ranch, 11 (basal part wanting).
10. Rock Crossing (lower, with basal part wanting).

homa, where it is found at the base at Rock Crossing, sec. 35, T. 5 S., R. 1 E. (C. E. Decker collector, 1931), on U. S Highway 77, West Branch of Sycamore Creek, at the Witch Hole, the northeast edge of Bromide, on the P. A. Norris ranch and 2 miles west of Nebo store. We figure from Rock Crossing a finely preserved specimen which is macerated sufficiently to bring out the sicula and the skeleton that usually is hidden by the periderm.

SUMMARY

The data secured for this paper come from measuring twelve sections of the Viola limestone and from collecting from detailed zones in eight of these sections. The measurements show a variation in thickness from 219 feet on the Robertson ranch 2½ miles south of Bromide at the east end of the mountains, to 929 feet on West Spring Creek at the west end. The Fernvale phase varies from 14 to 80 or 90 feet, and this does not differ much from the measurements given by Bassler for central Tennessee, 10–76 feet.[13]

The conglomerate at the base of the Viola limestone in the northeast part of the mountains and the clay bed at the base at Rock Crossing in the Criner Hills mark a zone which is represented 100 to 150 feet above the base in sections along the southwest edge of the mountains on the West Branch of Sycamore Creek, U. S. Highway 77, and on West Spring Creek. The very fossiliferous zone near the southeast edge of Double Mound southwest of Lawrence Quarry is represented by a zone about the middle of the Viola in the northeastern part of the mountains.

The Molluscoidea and mollusks, as well as the graptolites, correlate parts of the Viola with the Normanskill, Trenton, Utica, Lorraine, and Richmond. Thus far only two graptolites have been found in common in the Viola and the Stringtown shale and the evidence from the graptolites seems to indicate that most of the Viola is a little younger than the Stringtown shale. Some of the Viola graptolites are found in the Orodvician of Canada and Texas, and in the Hartfell shales of Scotland and Ireland.

In the wonderfully rich graptolite phase of the fauna ten genera and thirty species and varieties have been described, of which one species and three varieties are new.

[13] Bassler, R. S., *Tenn. Div. of Geology, Bull.* 38, pp. 125–233, 1932.

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MOHAWKIAN OSTRACODA: SPECIES COMMON TO TRENTON FAUNULES FROM THE HULL AND DECORAH FORMATIONS[1]

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ABSTRACT

The Ordovician Hull formation is the second of the formations of the Trenton group in Ontario, succeeding the Rockland formation. The Decorah formation, lying above the Platteville limestone and below the Prosser limestone in the upper Mississippi Valley, has three members, of which the upper, Ion member, is correlated with the Hull, the lower, Spechts Ferry and Guttenberg, members of the Decorah being of Black River Chaumont and Trenton Rockland age, respectively.

The evidence from the Ostracoda supports the correlation of the Ion with the Hull formation. Of twenty-one species identified from the Hull at Healey Falls, Northumberland County, Ontario, all but five occur also in the Ion member of the Decorah formation in Iowa. Six new genera are defined (*Punctaparchites*, *Hallatia*, *Thomasatia*, *Bassleratia*, *Bellornatia* and *Raymondatia*) and eleven of the fifteen species described are new.

STRATIGRAPHY

The Hull limestone, second of the formations of the standard Trenton group (see fig. 1), was defined by Raymond[2] with its type section at Hull, Quebec. A comprehensive description of the stratigraphy and paleontology of the formation has not been published; Kay has described the stratigraphy of the underlying Rockland formation in New York.[3]

Faunules containing ostracodes have been collected from low Trenton limestones at several localities and horizons in that part of Ontario between Orillia, Simcoe County, and Kingston, Frontenac County. The most prolific faunule was that collected 15 feet from the base of the shaly limestones on the north side of the abandoned channel of the Trent River south of Healey Falls, in Lot 15, Conc. XI, Seymour Township, 6 miles north and east of Campbellford, Northumberland County, Ontario. The beds are of low Hull age; the presence of the formation at this locality has been recorded by Raymond.[4]

The following species of ostracodes

[1] Presented before the Paleontological Society, Dec. 29, 1931, as "Mohawkian Ostracoda; Species common to Trenton faunules from the Rockland and Decorah formations": (Abstract) *Geol. Soc. America, Bull.*, vol. 43, pp. 268–269, 1932.

[2] Raymond, P. E., Trenton group in Ontario and Quebec: *Canada Geol. Survey, Summary Rept. for 1912*, p. 348, 1914.

[3] Kay, G. Marshall, Ordovician Trenton group in northwestern New York, Stratigraphy of the lower and upper limestone formations: *Am. Jour. Sci.*, 5th ser., vol. 26, pp. 1–16, 1933.

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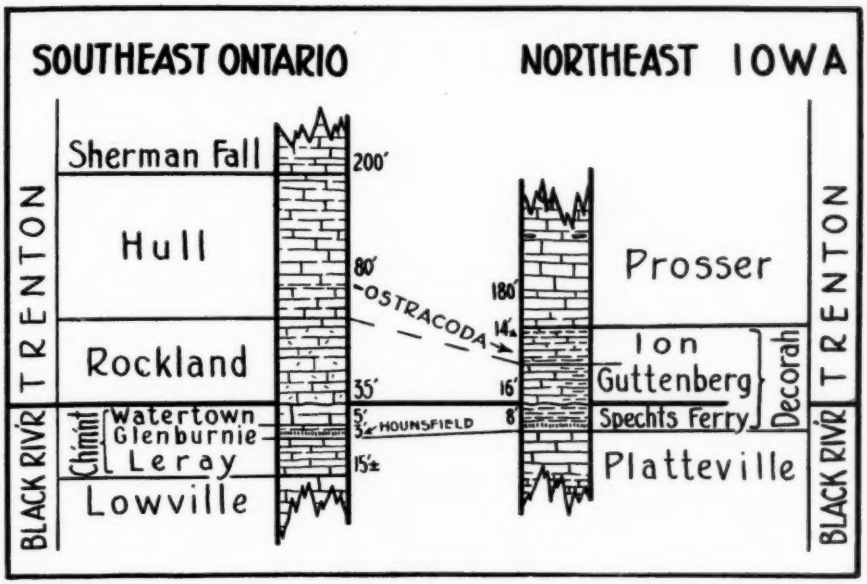

FIG. 1. Columnar sections of upper Black River and lower Trenton formations in Ontario and Iowa.

TABLE I.—*Hull Ostracode Faunule, Healey Falls, Ontario*

	Abundance		Described		
	Hull	Ion	Page	Plate	Figs.
Bassleratia typa Kay, n. gen., n. sp.	c*	f	341	46	1–12
Bellornatia tricollis Kay., n. gen., n. sp.	r	r	342	44	22–26
Beyrichia sp.	r				
Bollia subaequata Ulrich	a	a	336	44	6–16
Bythocypris sp. cf. *B. cylindrica* (Hall)	f	f			
Ceratopsis sp., cf. *C. quadrifida* (Jones)	r	u	340	44	27
Drepanella sp., cf. *D. crassinoda* (Ulrich)	u				
Eurychilina sp., cf. *E. reticulata* Ulrich	f	f			
Hallatia healeyensis Kay, n. gen., n. sp.	f		335	45	5, 6
Halliella labiosa Ulrich	f	f	332	44	17, 18
Halliella magnapuncta Kay, n. sp.	r	r	334	45	1, 2
Leperditia sp.	f				
Primitiella constricta Ulrich	c	f			
Primitiella sp.	c				
Punctaparchites rugosus (Jones), n. gen.	f	c	331	44	1–4
Punctaparchites ovatus Kay, n. sp.	f	c	332	44	5
Raymondatia goniglypta Kay, n. gen., n. sp.	u	u	342	45	7–9
Schmidtella sp., cf. *S. incompta* Ulrich	f	f			
Tetradella ellipsilira Kay, n. sp.	f	f	339	45	10–15
Tetradella ulrichi Kay, n. sp.	u	u	339	45	16–19
Thomasatia falcicosta Kay, n. gen., n. sp.	c	f	337	46	13–23

* The following abbreviations are used in referring to the abundance of fossils: "a," abundant; "c," common; "f," frequent; "u," uncommon; "r," rare. At the top of the table, the column headed by "Hull," Hull formation, Healey Falls; by "Ion," Ion member, Decorah formation, Iowa.

have been identified from this faunule (Table I). The occurrence of the species in the Ion member of the Decorah formation is annotated.

Other fossils observed in this shale bed were *Homotrypa minnesotensis* Ulrich and *Sowerbyella* sp. cf. *S. curdsvillensis* (Foerste).

The Decorah formation lies above the Platteville formation and below the Galena Prosser formation in northeastern Iowa (see fig. 1). The stratigraphy of the formation has been summarized[5] and the lowest member, the Spechts Ferry, correlated with the Glenburnie member of the Black River Chaumont formation of Ontario.[6]

A large number of ostracode faunules have been examined from the Decorah formation in Iowa and Minnesota; many of the species have been described by Ulrich.[7] The faunules from the low Hull formation support the view that the upper part of the Decorah formation, the Ion member, is of Trenton age.

The species in the low Hull faunules are with few exceptions present also in the Ion. Whereas some of the species may not be of significance because (1) of the questionable identity of species lacking distinctive characters (*Schmidtella incompta* and *Bythocypris cylindrica*, for example), (2) of the known extended range of the species (*Ceratopsis quadrifida* and *Tedradella ulrichi* range into the higher Sherman Fall, *Raymondatia goniglypta* and *Primitiella constricta* into the older Platteville), and (3) of the fragmentary character of the specimens (*Drepanella carssinoda* and *Eurychilina reticulata*), there are a few species that (1) have characters that insure their proper identification, (2) occur in some abundance in the faunules, and (3) have not been recognized in younger and older faunules. *Bassleratia typa* and *Thomasatia falcicosta* are striking examples of these most significant species.

The species described in the following pages are species common to the formations in the two regions, with the addition of two Ion species that are of importance in comparison. The discussion of the significance of the species is based on the study of faunules from the Chaumont formation (Glenburnie member) in Ontario, the Sherman Fall formation in Ontario and New York, and from the Platteville, Decorah (Guttenberg and Ion members), and Prosser formations in the upper Mississippi Valley.

Correlation.—The correlation of the Decorah formation in Iowa and the formations of the Black River and Trenton groups in Ontario may be summarized as follows. The Spechts Ferry member of the Decorah has been correlated with the Chaumont formation, Glenburnie member, because of the occurrence in the Glenburnie shale of a bryozoan fauna that seems homotaxial with that in the Spechts Ferry; in addition, it is be-

[5] Kay, G. Marshall, Stratigraphy of the Decorah formation: *Jour. Geology*, vol. 37, pp. 639–671, 1929.

[6] Kay, G. Marshall, *Idem*, p. 668; Stratigraphy of the Ordovician Hounsfield Metabentonite: *Jour. Geology*, vol. 39, p. 370, 1931.

[7] Ulrich, E. O., Lower Silurian Ostracoda of Minnesota: *Geol. Minnesota*, vol. 3, pt. 2, pp. 629–693, pls. 43–46, 1894.

lieved that the metabentonite occurring near the base of the Spechts Ferry is identical to the Hounsfield metabentonite in the Glenburnie.

The Guttenberg member of the Decorah formation has been correlated in the past with the Watertown member of the Chaumont. The correlation has been principally on stratigraphic position; the occurrence of *Gonioceras kayi* Foerste in the Guttenberg was suggestive because no species of the genus has been reported from beds younger than Black River. However, the limits of possible stratigraphic position are altered by the correlation of the succeeding Ion member of the Decorah with the Hull rather than the Rockland, as shown in this paper; and *G. kayi* has been collected in the Rockland "*Dalmanella* beds" near Millington, Victoria County, Ontario. Considering the additional fact that characteristic Trenton genera such as *Dalmanella* and *Sowerbyella* are common in the Guttenberg, the member should be correlated with the Rockland formation of the Trenton group.

The striking similarity in the Ostracoda of the Ion member of the Decorah and the lower Hull formation of Ontario strongly supports the view that they are of similar age. The associated faunas of other classes of organisms accord with this correlation.

SYSTEMATIC DESCRIPTIONS

Family APARCHITIDAE Ulrich and Bassler, 1923

Genus PUNCTAPARCHITES Kay, n. gen.

Genoholotype *Cytheropsis rugosus* JONES, *1858*, Annals Mag. Nat. Hist., vol. 1, (3), p. 249, pl. 10, fig. 5. (Block of limestone, perhaps of Rockland age, from Pauquette Rapids, Ottawa River, above Waltham, Pontiac County, P. Q.)

Primitia rugosa (Jones) JONES and HOLL, *1868*, Annals Mag. Nat. Hist., vol. 2, (4), p. 55.

Cytherella (?) *rugosa* JONES, *1891*, Canada Geol. Survey, Cont. Micro-Pal., pt. 3, p. 99.

Valves small, equal; outline oval or suboval, dorsally truncated; hinge straight or slightly concave; surface regularly convex, with numerous distinct pits. Contact plane, valves exactly equal.

Ordovician.

In addition to the two species about to be described, the genus includes *Cytherella* (?) *arcta* Ulrich of the upper Decorah formation (Ion member).

PUNCTAPARCHITES RUGOSUS (Jones), 1858, n. comb.

Plate 44, figures 1–4

Cytheropsis rugosus JONES, *1858*, Annals Mag. Nat. Hist., vol. 1, (3) p. 249, pl. 10, fig. 5 (Trenton (?), Pauquette Rapids, Ottawa River).

Cytherella (?) *rugosa* ULRICH, *1894*, Geol. Minnesota, vol. 3, pt. 2, p. 686, pl. 43, figs. 21–24.

Valves small, equal. Outline subelliptical, narrowing anteriorly; dorsal margin slightly concave to straight, other margins regularly curved; anterior more sharply convex than posterior; retral swing obvious. Surface rising abruptly from margins at dorsal and ventral, giving rectangle profile; otherwise regularly convex, slightly depressed anterior to center; greatest thickness mid-height and posterior to mid-length; greatest length dorsal to mid-height. Ornamented by numerous distinct punctae, largest mid-anterior and mid-posterior, reaching diameter of 0.03 to 0.04 mm., interspaces a little wider than punctae.

Plesiotype No. 27486 C[8] (Ion member, Decorah formation, Iowa): length, 0.94 mm.; width, 0.55 mm.; thickness, 0.42 mm. 27569 C. (low Hull formation, Healey Falls): length, 0.81 mm.; width, 0.48 mm.; thickness one valve, 0.21 mm. 41814 US. (Prosser formation, Minnesota)—Ulrich.

Frequent in Hull formation, Healey Falls, Ontario; abundant in Ion member, Decorah formation and Guttenberg member, Decorah formation, Iowa and Minnesota; present in Prosser formation, Minnesota (Ulrich).

This species is similar to species of the genus *Aparchites* Jones in shape and equality of the valves, but has the pits that distinguish the genus *Punctaparchites*. The species *P. arcta* (Ulrich) is subcuneate, much narrower anteriorly. The Hull and Decorah specimens are indistinguishable from the excellent illustrations of the holotype.

PUNCTAPARCHITES OVATUS Kay, n. sp.

Plate 44, figure 5

Valves small, equal. Outline nearly elliptical; dorsal margin slightly convex, ventral little more so; anterior and posterior margins subequal, former very little more convex; free margins regularly curved; hinge line short; retral swing not discernible and orientation of valve often difficult. Surface regularly convex, greatest thickness central or little dorsal to center; distinct, subcircular, irregularly arranged pits, thirty to forty in number, distributed over all but borders of valve, often not obvious because of filling. Contact of valves evidently plane, somewhat obscured by overhanging dorsal margin; valves seem exactly equal.

Holotype No. 27534 C. (low Hull formation, Healey Falls): length, 0.40 mm.; width, 0.28 mm.; thickness one valve, 0.13 mm. Paratypes Nos. 27489 C. (Ion member, Decorah formation, Iowa): length, 0.53 mm.; width, 0.33 mm.; thickness, one valve, 0.16 mm.; 6252 GSC. (low Hull formation, Healey Falls): length, 0.48 mm.; width, 0.33 mm.; thickness 0.15 mm.; 82282 US. (Ion member, Decorah formation, Iowa): length, 0.54 mm.; width, 0.31 mm.; thickness, 0.14 mm.; 9–901 I. (same): length 0.53 mm.; width, 0.31 mm.; thickness, 0.15 mm.

Frequent in Hull formation, Healey Falls, Ontario; abundant in Ion member, Decorah formation at many localities.

This species differs from others of the genus in its smaller size and nearly elliptical outline. The Ion specimens are relatively longer than the types, but agree in other characters.

Family PRIMITIIDAE Ulrich and Bassler, 1923

Genus HALLIELLA Ulrich, 1891

Genotype (designated by Bassler, 1915) *Primitia* (?) *sculptilis* ULRICH, *1890*, Cincinnati Soc. Nat. Hist., Jour., vol. 13, p. 136, pl. 8, fig. 6.—*Halliella sculptilis* ULRICH, idem, p. 184. (Trenton, Perryville formation, Perryville, Kentucky.)

Halliella ULRICH, *1890*, Cincinnati Soc. Nat. Hist., Jour., vol. 13, p. 184; *1894*, Geol. Minnesota, vol. 3, pt. 2, p. 656.—ULRICH and BASSLER, *1923*, Maryland Geol. Survey, p. 300.

Valves small, equal. Outline suboval; surface gently convex with central or dorsomedian sulcus; pits adjacent to sulcus arranged in varying ways; margin with false border on ventral and posterior. Contact plane, commonly obscured by margin.

Ordovician to Devonian.

HALLIELLA LABIOSA Ulrich, 1894

Plate 44, figures 17, 18

Halliella labiosa ULRICH, *1894*, Geol. Minnesota, vol. 3, pt. 2, p. 656, pl. 46, figs. 43–46. (*Nematopora* bed, Prosser formation, Goodhue County, Minnesota.)

Valves small, equal. Outline dorsally truncated elliptical, approaching subcircular; ends subequal; posterodorsal

[8] Museum numbers are represented as C., Columbia University; GSC., Geological Survey of Canada, Ottawa; I., State University of Iowa, Iowa City; T., Royal Ontario Museum, Toronto; and US., United States National Museum, Washington.

angular. Surface of valve gently convex; free margins rising abruptly, overhanging contact; dorsal extremities somewhat depressed. False border on free margins, with narrow and shallow groove within, this groove being somewhat wider in posteroventral; center of valve somewhat elevated above border, with sulcus dorsal to middle of valve very slightly convex to posterior; broader and deeper toward middle of valve, narrow toward dorsal margin. Area within false border having numerous subcircular pits arranged more or less in quincunx; pits of little larger diameter than width of interspaces; occasionally pits seem in concentric rows roughly parallel to ventral margin; surface of valve between pits without linear ridges such as characterize the next described species, *H. linepunctata* Kay. Contact obscured except at dorsal extremities by overhanging border and projecting dorsal margin; border somewhat concave in profile; hinge line almost as long as valve, ends subequal and a little obtuse angular; interior having partition corresponding in position to sulcus on exterior. Contact plane; valves evidently exactly equal.

Plesiotypes No. 27483 C. (low Hull formation, Healey Falls): length, 0.805 mm.; width, 0.54 mm.; thickness one valve, 0.19 mm. No. 6253 GSC. (same): length, incomplete; width, 0.60 mm.; thickness one valve, 0.24 mm. No. 82283 US. (same): length, 0.88 mm.; width, 0.62 mm.; thickness one valve, 0.26 mm. No. 27539 C. (same). Paratype No. 27538 C. (base Ion member, Decorah formation, Iowa): length, 0.76 mm.; width, 0.54 mm.; thickness one valve, 0.18 mm. Holotype No. 41361 US. (Prosser formation, Minnesota): length, 0.82 mm.; width, 0.62 mm.; thickness, 0.40 mm.

Frequent in Hull formation at Healey Falls, Ontario; uncommon in Ion and Guttenberg members, Decorah formation, northeastern Iowa.

The specimens from the two localities are not truly identical, but are very similar and there is some variation in the arrangement of the punctae, which tend in some specimens to form linear rows. The species is most like *Halliella linepunctata* Kay, which does not occur in Ontario, but is a common species in the Iowa beds. The description will be introduced for comparison.

HALLIELLA LINEPUNCTATA Kay, n. sp.
Plate 44, figures 19–21

Valves small, equal. Outline dorsally truncate elliptical; posterodorsal extremity somewhat angular, producing right or slightly acute angled margin; ends subequal; retral swing not obvious. Surface of valve slightly and irregularly convex; free margins rising abruptly from contact, that of ventral overhanging it considerably; gentle slope toward dorsal margin, which extends beyond hinge line; false border on free margins; defining a deep, relatively broad depression in posteroventral; small, comma-shaped sulcus dorsal to middle of valve, slightly convex posteriorly.

Ornamentation striking, consisting of arcuate rows of small pits, the arcs being roughly parallel but a little less convex than ventral margin; commonly about fifteen rows of subquadrangular pits extending through posterior depression and continuous on two sides of median sulcus, ending abruptly within false border and not covering rather truncated dorsal extremities; those in ventral quite regular, those in dorsal part tending to bifurcate and overlap, not to be so continuous; between rows are narrow linear ridges obvious when light strikes specimen from low dorsal; pits somewhat variable in size, commonly 0.03 to 0.04 mm. from center to center, often not obvious except when specimen is moistened. Contact obscured by overhanging margin; plane; hinge line straight, almost as long as valve, having nearly right-angled posterior extremity, slightly obtuse at anterior.

Holotype No. 27482 C. (5 feet from top Ion member, Decorah formation,

sec. 6, Glenwood tp., Winneshiek County, Iowa): length, 0.69 mm.; width, 0.48 mm.; thickness one valve, 0.17 mm. Paratypes No. 27488 C. (same): length, 0.68 mm.; width, 0.48 mm.; thickness one valve, 0.21 mm. 9–903 I. (same): length, 0.70 mm.; width, 0.49 mm.; thickness one valve, 0.20 mm.

Frequent to common in nearly all outcrops of Guttenberg and Ion members, Decorah formation, Iowa and Minnesota; present in Prosser formation, *Nematopora* bed, in Minnesota (Ulrich).

This species tends to be a little more elongate than the last, and to have a broader posteroventral depression, but the striking difference is in the ornamentation. The pits in *H. linepunctata* are obscure, arranged in concentric arcs, and separated by narrow linear ridges; in *H. labiosa* they are obvious, arranged more or less irregularly, commonly in quincunx, not in consistently arcuate rows though frequently tending to have this arrangement, and without intervening linear ridges. The next species, *H. magnapuncta*, is not similar to these, but is closely related to the genotype, *H. sculptilis* (Ulrich).

Halliella magnapuncta Kay, n. sp.
Plate 45, figures 1, 2

Valves small, equal. Outline dorsally truncated elliptical; ends subequal, posterior more broadly arcuate; posterodorsal extremity angular; retral swing not obvious but discernible. Valves gently convex; greatest thickness ventral to mid-height; cardinal extremities depressed; border with marginal ridge,

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Explanation of Plate 44

The formation from which each specimen comes has been indicated. A dot beneath the number means that the specimen is from the Decorah formation, Iowa; a dash, that it is from the Sherman Fall formation, Lot 12, Conc. I, Mara Township, Victoria County, Ontario; when without designation, the specimen is from the lower part of the Hull formation at Healey Falls, Northumberland County, Ontario.

Most of the illustrations are from somewhat retouched photographs of specimens that have been whitened by ammonium chloride. Unless otherwise indicated (by a cross above the number and statement in explanation of plate), the magnification is about thirty diameters.

Figs. 1–4—*Punctaparchites rugosus* (Jones), n. gen., Kay. 1–3, Plesiotype 27486 C, upper Ion member, Decorah formation, Iowa; 1, left valve; 2, right valve; 3, anterior. 4, Plesiotype 27569 C, Hull formation, Ont. Left valve. (p. 331)

5—*Punctaparchites ovatus* Kay, n. sp. Holotype 27534 C, Hull formation, Ont. Left valve. (p. 332)

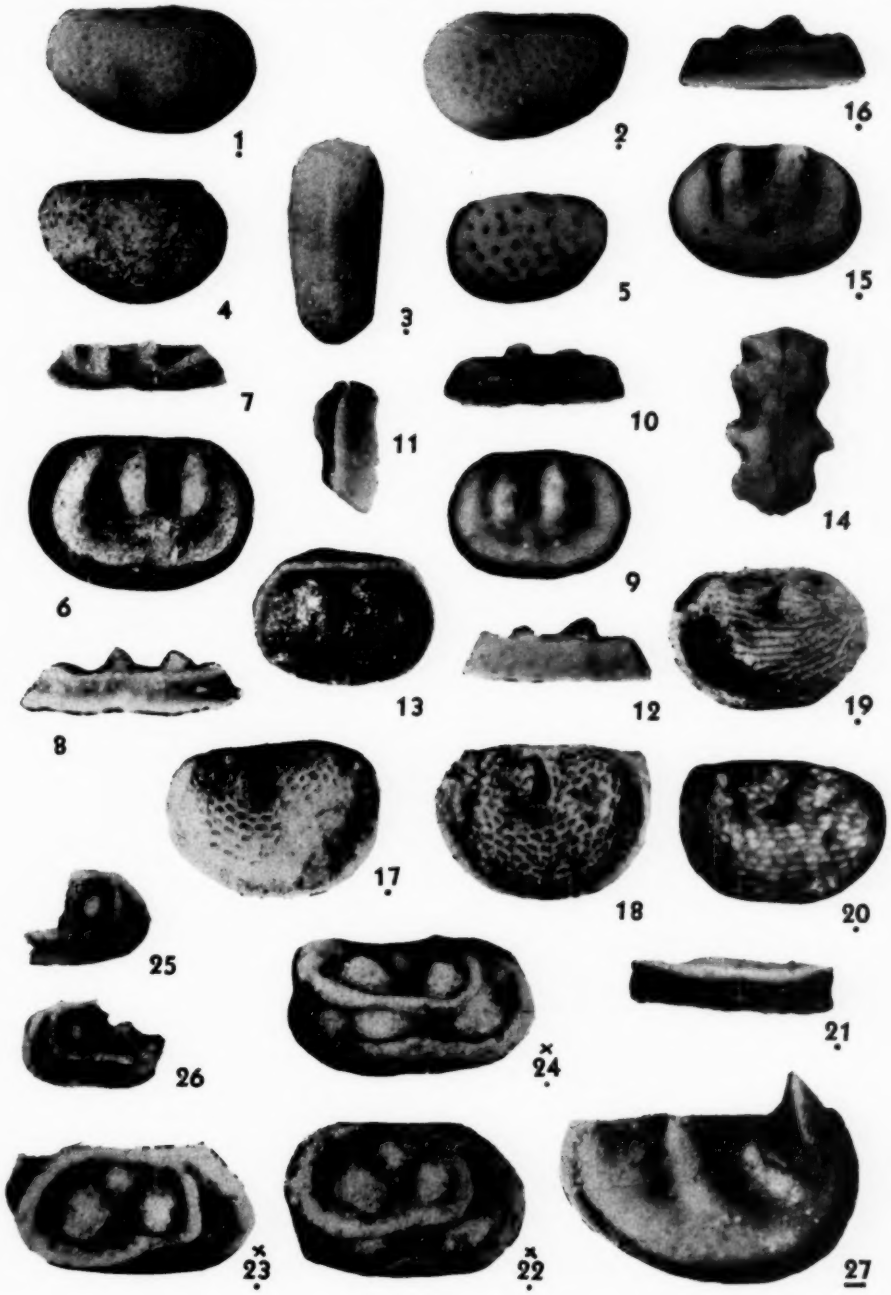
6–16—*Bollia subaequata* Ulrich. 6–8, Plesiotype 27566 C, Hull formation, Ont.; 6, left valve of this relatively large specimen; 7, dorsal; 8, ventral. 9–13, Homeotype (plesiotype) 27536 C, Hull formation, Ont.; 9, left valve of characteristic specimen of species; 10, interior; 11, dorsal; 12, anterior; 13, ventral. 14, Plesiotype 27537 C, Hull formation, Ont. Dorsal of specimen having both valves. 15, 16, Plesiotype 27490 C, Ion member, Decorah formation, Iowa; 15, left valve; 16, ventral. (p. 336)

17, 18—*Halliella labiosa* Ulrich. 17, Left valve. Plesiotype 27538 C, base of Ion member, Decorah formation, Iowa. 18, Left valve. Plesiotype 27539 C, Hull formation, Ont. (p. 332)

19, 21—*Halliella linepunctata* Kay, n. sp. 19, Right valve, illustrating linear ridges between rows of punctae. Paratype 27482 C, upper Ion member, Decorah formation, Iowa. 20, Right valve. 21, Ventral. Holotype 27488 C, upper Ion member, Decorah formation, Iowa. (p. 333)

22–26—*Bellornatia tricollis* Kay, n. gen. and sp. 22–24, Holotype 27480 C, upper Ion member, Decorah formation, Iowa. Illustrations about ×50. 22, Right valve; 23, dorso-lateral; 24, ventro-lateral. 25, 26, Paratypes 27540 C and 27541 C, Hull formation, Ont.; 25, anterior part of right valve, 26, anterior part of left valve. (p. 342)

27—*Ceratopsis quadrifida* (Jones). Plesiotype 27542 C, Sherman Fall formation, Ont. Left valve. (p. 340)



Kay, Ordovician ostracodes

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forming false border along anteroventral, ventral and posterior margins, separated from central part of valve by distinct groove, a little the broadest at posterior; surface within continuous with border at anterior, elevated above it posteriorly; well defined sinus dorsal to middle of valve, shape of inverted comma, convexity to posterior, ventral portion enlarged, rather deep; dorsal extension deflected anteriorly, shallow; low node just anterior to sulcus. Relatively large, elliptical pits, somewhat less than thirty in number, distributed around sulcus within false border, except that node and anterodorsal part of valve are smooth; two or three unorderly rows between sulcus and border, single row anterior to node. Contact and margin quite coextensive; border rising rather abruptly from contact, particularly on ventral margin; hinge line straight, quite as long as greatest length; valves seem exactly equal.

Holotype No. 27481 C. (5 feet from base Ion member, Decorah formation, sec. 13, Glenwood tp., Winneshiek County, Iowa): length, 0.94 mm.; width, 0.62 mm.; thickness one valve, 0.28 mm. Paratypes, No. 9–904 I. (base Ion member, Decorah formation, Iowa): length, 0.90 mm.; width, 0.59 mm.; thickness incomplete. 82284 US. (same): length, 0.79 mm.; width, 0.52 mm.; thickness one valve, 0.25 mm. 6245 GSC. (same): length, 0.90 mm.; width, 0.59 mm.; thickness one valve, 0.28 mm. 6244 GSC. (Hull formation, Healey Falls): length, incomplete; width, 0.38 mm.; thickness, 0.15 mm.

Rare in Hull formation at Healey Falls, Northumberland County, Ontario; frequent in Guttenberg and uncommon in Ion member, Decorah formation, Iowa.

This species is similar to the genotype, *H. sculptilis* Ulrich of the upper Trenton of Kentucky. That form has a median sulcus that widens and becomes broad and shallow toward the posterior; it is not central, but is posterior to central. The pits are distributed over the whole surface including the anterodorsal of the valve.

Genus HALLATIA Kay, n. gen.

Genotype, *H. healeyensis* Kay, next described.

Valves small, seemingly equal. Outline suboval, hinge line relatively long. Surface smooth, relatively plane with sharp borders, particularly on ventral and posterior; with distinct median sulcus, and depressed posterior or posteroventral.

This genus in general form is similar to the genus *Halliella*, particularly to such species as *H. magnapuncta;* it lacks the pits or punctae of that genus. It differs from the genus *Primitia* in its sharply defined median sulcus, and particularly the truncation of the generally elevated surface toward the posterior, that part of the valve being depressed. The name is an arbitrary combination of letters, suggesting a similarity to *Halliella*.

HALLATIA HEALEYENSIS Kay, n. sp.
Plate 45, figures 5, 6

Valves relatively small, equal. Outline dorsally truncated ellipse; margin regularly curved; posterior extremity of dorsal margin more angular than anterior; slight retral swing. Surface of valve convex normal to length, rather straight along length; greatest thickness posterior to center of valve. Generally elevated surface terminated near to posterior margin and depressed to posterior; termination along sinuous cord truncating posterior margin about at right angles to hinge line, this line convex to posterior in dorsal part, concave in ventral part; elevated and angular along posterior margin. Sharply defined crescentic sulcus dorsal to middle of valve, extending almost to dorsal margin, concave posteriorly; surface smooth. Contact seemingly plane; no specimens with two valves observed.

Holotype No. 27544 C. (low Hull formation, Healey Falls, Ontario): length,

0.98 mm.; width, 0.63 mm.; thickness one valve, 0.28 mm. Paratype No. 27543 C. (same): length, 0.77 mm.; width, 0.47 mm.; thickness one valve, 0.23 mm.

Frequent in Hull formation at Healey Falls, Northumberland County, Ontario.

The species differs obviously from the next, *H. particylindrica*, an Ion species, in that the posterior termination of the elevated portion of the surface is a sinuous curve, whereas in the Ion form, there is a posteroventral marginal sulcus.

HALLATIA PARTICYLINDRICA Kay, n. sp.
Plate 45, figures 3, 4

Valves small, equal. Outline dorsally truncated ellipse; margin regularly curved; posterior extremity of dorsal margin more angulate than anterior; slight retral swing. Surface of valve convex normal to length, somewhat concave along it; with greatest thickness adjacent to posterior margin. Border of valve with narrow groove within it on anteroventral and ventral border; at posterior is a broad step between the general surface of the valve and the margin. Sharply defined crescentic to suboval sulcus dorsal to middle of valve, extending almost to dorsal margin; surface of valve very smooth. Contact plane.

Holotype No. 27525 C. (4 feet from top, Ion member, Decorah formation, sec. 6, Glenwood tp., Winneshiek County, Iowa): length, 0.92 mm.; width, 0.51 mm.; thickness one valve, 0.22 mm.

Rare in Ion member of Decorah formation in Iowa.

Genus BOLLIA Jones and Holl, 1886

Genotype (designated by Ulrich, 1894) *B. uniflexa* JONES and HOLL, *1886*, Annals Mag. Nat. Hist., vol. 17 (5), p. 361, pl. 12, figs. 17*a–b*. Silurian, Wenlock shale, Woolhope, England.

Bollia JONES AND HOLL, *1886*, Annals. Mag. Nat. Hist., vol. 17 (5), p. 360.—ULRICH, *1894*, Geol. Minnesota, vol. 3, pt. 2, p. 668.—ULRICH and BASSLER, *1923*, Maryland Geol. Survey, Silurian, p. 301.

Valves small, equal. Outline suboval. Surface moderately convex with distinct median sulcus; nodes on either side connected ventrally to form a U-shaped loop. Contact plane; border often thickened or elevated.

Ordovician to Devonian.

BOLLIA SUBAEQUATA Ulrich, 1894
Plate 44, figures 6–16

Bollia subaequata ULRICH, *1894*, Geol. Minnesota, vol. 3, pt. 2, p. 669, pl. 46, figs. 26–29. (Prosser formation, Clitambonites bed, Cannon Falls, Goodhue County, Minnesota.)

Valves small, equal. Outline elliptical, rather short, and dorsally truncated; dorsal margin straight, short; free margins forming continuous curve; ends subequal, retral swing not evident. Free margins paralleled by distinct, fairly broad, rounded ridge, which commonly rises abruptly from margin; in some speci-

EXPLANATION OF PLATE 45

FIGS. 1, 2—*Halliella magnapuncta* Kay, n. sp. Holotype 27481 C, lower Ion member, Decorah formation, Iowa; 1, left valve; 2, dorso-lateral. (p. 334)

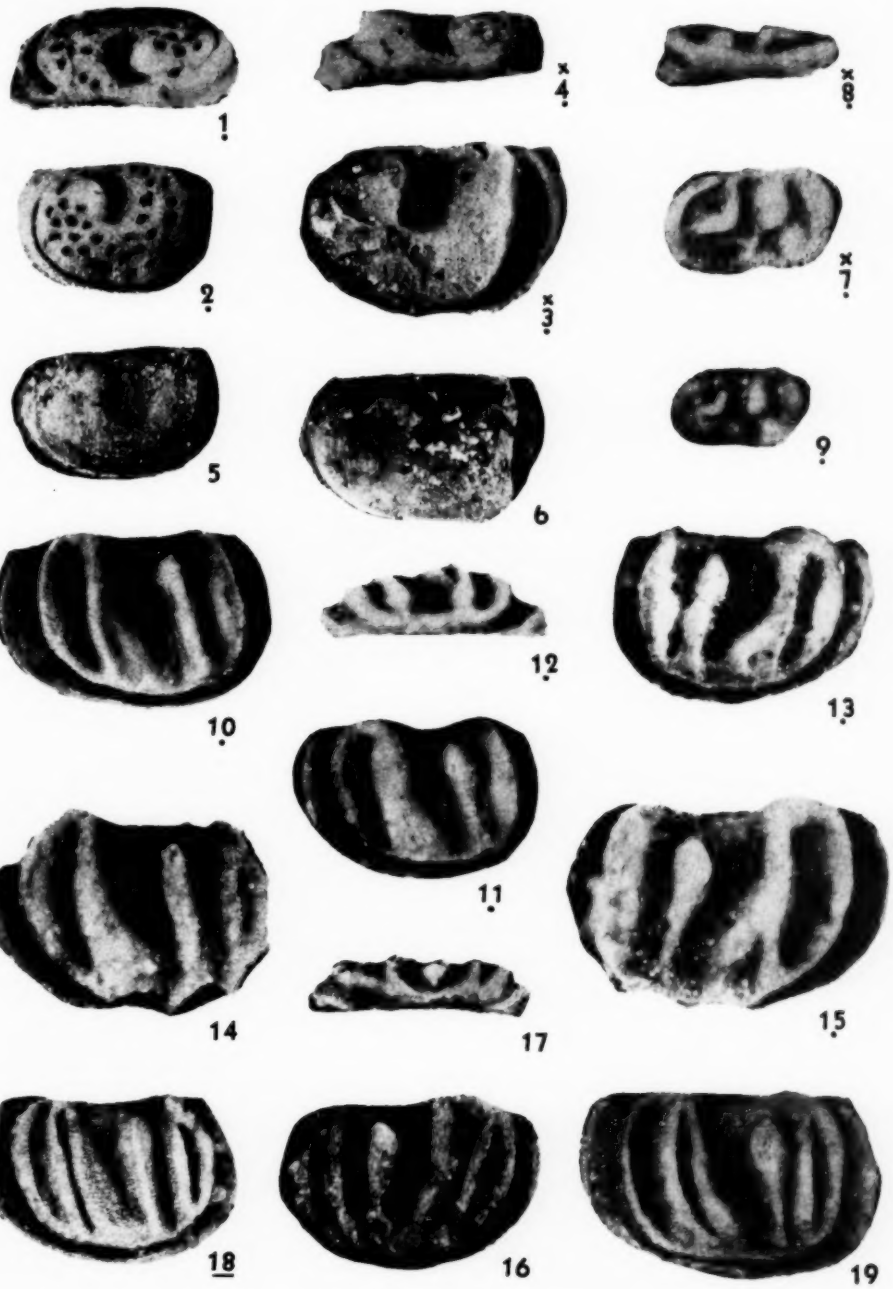
3, 4—*Hallatia particylindrica* Kay, n. sp. Holotype 27525 C, upper Ion member, Decorah formation, Iowa, ×50; 3, left valve, 4, dorsal. (p. 336)

5, 6—*Hallatia healeyensis* Kay, n. gen. and sp. 5, Paratype 27543 C, Hull formation, Ont. Left valve. 6, Holotype 27544 C, Hull formation, Ont. Left valve. (p. 335)

7–9—*Raymondatia goniglypta* Kay, n. gen. and sp. Holotype 27484 C, base Ion member, Decorah formation, Iowa; 7, left valve (×50); 8, dorsal (×50); 9, left valve. (p. 342)

10–15—*Tetradella ellipsilira* Kay, n. sp. 10, Paratype 27526 C, basal Ion member, Decorah formation, Iowa. Left valve. 11, 12, Holotype 27485 C, base Ion member, Decorah formation, Iowa; 11, left valve; 12, dorsal. 13, Paratype 27546 C, base Ion member, Decorah formation, Iowa; right valve. 14, Paratype 27529 C, Hull formation, Ont.; left valve. 15, Paratype 27523 C, base Ion member, Decorah formation, Iowa, right valve. (p. 339)

16–19—*Tetradella ulrichi* Kay, n. sp. 16, 17, Holotype 27487 C, Hull formation, Ont.; 16, right valve; 17, dorsal. 18, 19, Paratypes 27528 and 27527 C, Sherman Fall formation, Ont. Each a left valve. (p. 339)



Kay, Ordovician ostracodes

mens, surface of valve slopes gently from ridge to margin, often in distinctly concave slope, the concavity being most evident on posterior border; within marginal ridge is distinct U-shaped loop that is sharply defined and separated from border ridge by distinct depression; two limbs of loop commonly little diverging dorsally, often quite parallel; anterior limb more prominent, extending ventrally from little anterior to middle of dorsal margin to mid-ventral, then turning broadly to a point anterior to posterodorsal extremity, hardly reaching dorsal margin; dorsal end of anterior limb occasionally extending beyond dorsal margin, having distinct dorsal node, often little dorsal to mid-height. Contact plane border without beading; valves seemingly exactly equal.

Holotype (Ulrich): length, 0.6 mm.; width, 0.4 mm.; thickness, 0.35 mm. Plesiotypes, No. 27490 C. (Ion member, Decorah formation, Iowa): length, 0.63 mm.; width, 0.47 mm.; thickness one valve, 0.18 mm. 9–905 I. (same): length, 0.58 mm.; width, 0.44 mm.; thickness one valve, 0.17 mm. 82285 US. (same): length, 0.61 mm.; width, 0.44 mm.; thickness one valve, 0.19 mm. Plesiotypes, No. 6247 GSC. (low Hull formation, Healey Falls): length, 0.62 mm.; width, 0.46 mm.; thickness one valve, 0.16 mm. 27491 C. (same): length, 0.63 mm.; width, 0.44 mm.; thickness one valve, 0.18 mm. 27566 C., 27356 C., 27537 C. (same). In a large number of specimens the lengths reach as much as 0.80 mm. and the widths average about seven-tenths the lengths; but range from about six-tenths to eighty-five hundredths.

Abundant in nearly all prolific Trenton faunules, as in the Hull formation at Healey Falls, Ontario; the Sherman Fall formation at Gamebridge, Ontario and Copenhagen, New York; the Decorah and Prosser formations in Iowa and Minnesota.

Though there is considerable variation in this species among horizons and localities, and from single faunules, no specific distinctions have been established in this paper. The species seems the most dependable in distinguishing Black River and Trenton faunules, for its lower limit of occurrence seems to coincide with the contact of the Trenton and Black River groups; and its abundance in Trenton faunules increases its usefulness; it has been found within the basal foot of the Hull formation and of the Ion member of the Decorah formation, but never in the Chaumont formation or the Guttenberg member of the Decorah.

Family ZYGOBOLBIDAE Ulrich and Bassler, 1923

Genus THOMASATIA Kay, n. gen.

Genoholotype *T. falcicosta* Kay, n. sp., next described.

Valves small, equal. Outline subrectangular to subelliptical, dorsally truncated; ends unequal, retral swing commonly obvious. Marginal ridge on posterior and ventral; elevated ridge within on the same borders, with distinct node within and just posterior to middle of valve. Contact obscured by overhanging or carinate border; plane, without thickening. The name is in honor of the late Dr. A. O. Thomas, of the University of Iowa.

Ordovician.

The genus includes the next described species, an undescribed low Hull species, and the species *Beyrichia richardsoni* Miller, 1874, = *Drepanella canadensis* Ulrich, 1890, the last being from Cincinnatian formation.

THOMASATIA FALCICOSTA Kay, n. sp.
Plate 46, figures 13–23

Valves small, equal. Outline quadrilateral to subelliptical; anterodorsal extremity extended; dorsal margin somewhat irregular; ventral margin straight to gently arcuate; anterior obliquely curved, meeting venter in rounded obtuse angle; posterior regularly convex; retral swing obvious. Margin with dis-

tinct ridge on posterior and venter, somewhat depressed on anterior; within this a ridge trending ventrally from posterior of dorsal margin, continuing within marginal ridge to mid-anterior, there ending abruptly; this ridge elevated; elongate node or ridge, much elevated at anterior, extends along dorsal margin from anterior to middle, somewhat continuous with marginal ridge to posterior; this ridge, broadest toward anterior, is higher than short ridge connecting it with second ridge anterior to its mid-venter; the connecting ridge trending a little posterior to ventral just anterior to middle of valve, broad and poorly defined anteriorly; within depressed area posterior to this ridge and within second ridge is a dorsoventrally elongate elliptical node, occasionally connected ventrally to second ridge by low, narrow extension. Contact of valves obscured by margin which overextends it slightly on free margins, and by projections of dorsal nodes; hinge line straight, nearly as long as greatest length, extremities angular, anterior almost right angle, posterior quite obtuse; contact plane; valves seem exactly equal.

Holotype No. 27535 C. (low Hull formation, Healey Falls, Ont.): length, 0.82 mm.; width, 0.445 mm.; thickness one valve, 0.22 mm. Paratypes, No. 27478 C. (same): length, 0.83 mm.; width, 0.47 mm.; thickness one valve, 0.25 mm. 82286 US. (same): length, 0.77 mm.; width, 0.46 mm.; thickness one valve, 0.24 mm. 970 T. (same), 9–906 I. (same), 6249 GSC. (same). Paratypes, No. 27479 C. (Ion member, Decorah formation, Iowa): length, 0.75 mm.; width, 0.46 mm.; thickness one valve, 0.24 mm. 27533 C. (base Ion member, Decorah formation, Iowa): length, 0.65 mm.; width, 0.39 mm.; thickness one valve, 0.23 mm. 27567 C. (Ion member, Decorah formation, Iowa): length, 0.75 mm.; width, 0.46 mm.; thickness one valve, 0.24 mm.

Frequent in Hull formation, Healey Falls, Ontario; frequent to common in lower Ion member of Decorah formation; uncommon in upper Ion member, Iowa and Minnesota.

This species is most similar to those of the genus *Drepanella*, which, however, are characterized by a single L-shaped ridge rather than the parallel ones, and by their having short interrupted ridges and nodes rather than the more continuous ones present in this species. The Iowa and Ontario specimens are indistinguishable. The specific name has reference to the sickle-shaped ridge within the border.

Family BEYRICHIIDAE Ulrich, 1894

Genus TETRADELLA Ulrich, 1890

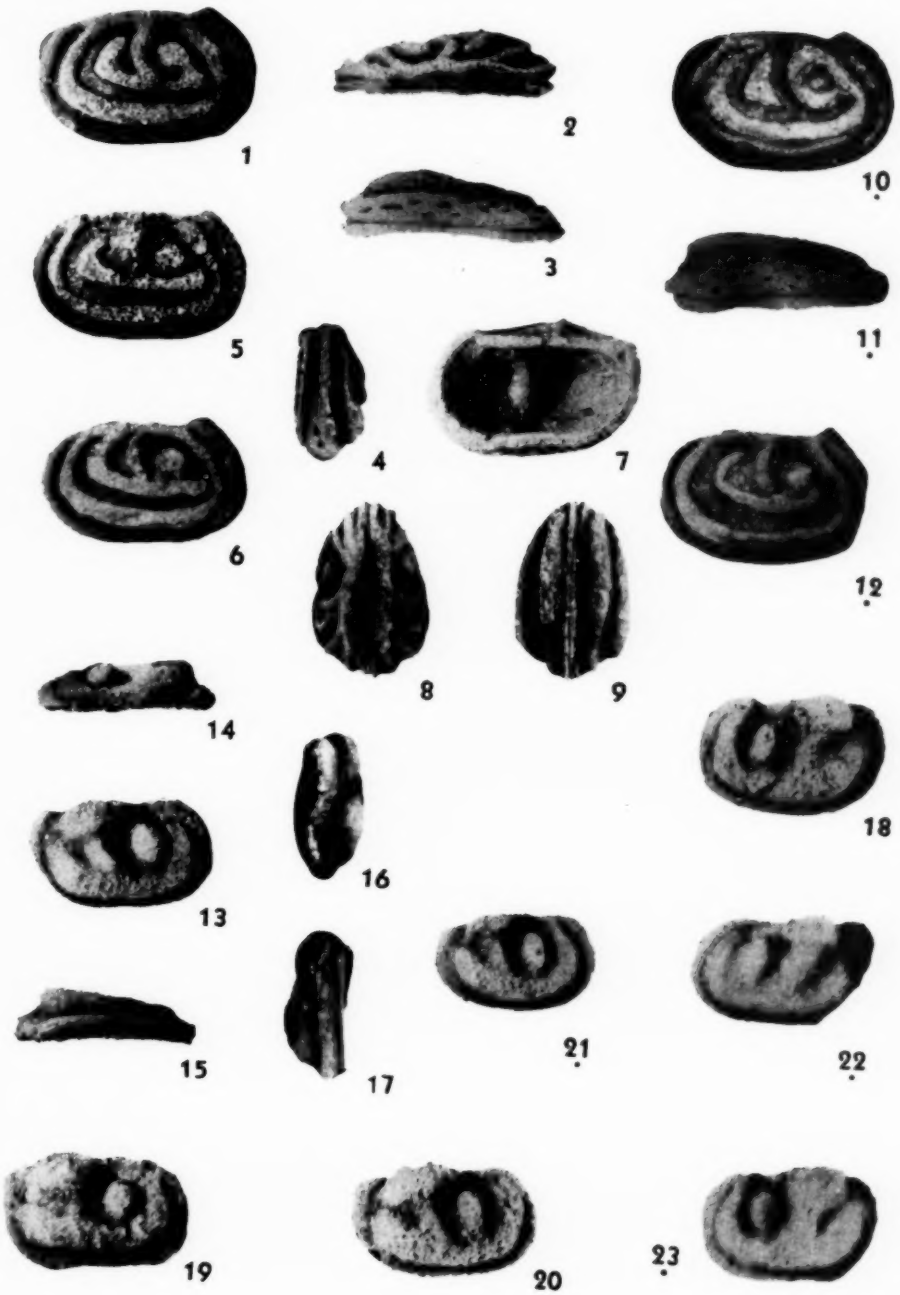
Genotype (designated by Ulrich and Bassler, 1923) *Beyrichia quadrilirata* HALL and WHITFIELD, *1875*, Ohio Geol. Survey, Paleontology, vol. 2, p. 105, pl. 4, figs. 6–7. (Richmond group, Ohio.)

Tetradella ULRICH, *1890*, Cincinnati Soc. Nat. Hist., Jour., vol. 13, p. 112; *1894*, Geol. Minnesota, vol. 3, pt. 2, p. 677.—ULRICH and BASSLER, *1909*, Nat. Mus., Proc., vol. 35, p. 306; *1923*, Maryland Geol. Survey, Silurian, p. 311.

EXPLANATION OF PLATE 46

FIGS. 1–12—*Bassleratia typa* Kay, n. gen. and sp. 1–9, Hull formation, Healey Falls, Ont. 1, Left valve; 2, dorsal; 3, ventral; 4, anterior; all of holotype 27512 C. 5, Left valve, Paratype 27476 C. 6, Left valve; 7, anterior; paratype 27530 C. 8, Dorsal; 9, ventral; paratype 27531 C. 10–12, Basal Ion member, Decorah formation, Iowa. 10. Left valve; 11, ventral; paratype 27477 C. 12, Left valve, paratype 27532 C. (p. 341)

13–23—*Thomasatia falcicosta* Kay, n. gen. and sp. 13–20, Rockland formation, Healey Falls, Ont. 13, Left valve; 14, dorsal; 15, ventral; 16, anterior; 17, posterior; holotype 27535 C. 18, Right valve; paratype 27478 C. 19, Left valve, paratype 6249 GSC. 20, Left valve, paratype 82286 US. 21–23, Decorah formation, Iowa. 21, Left valve, paratype 27533 C, base Ion member. 22, Right valve, paratype 27534 C, lower Ion. 23, Right valve, paratype 27479 C, lower Ion. (p. 337)



Kay, Ordovician ostracodes

Valves small, equal. Outline subquadrate to suboval, dorsally truncated. Surface irregularly convex, with four more or less distinct vertical ridges connected ventrally and often divided. Contact plane, border thickened.

Ordovician.

TETRADELLA ELLIPSILIRA Kay, n. name

Plate 45, figures 10–15

Tetradella quadrilirata ULRICH, *1894*, Geol. Minnesota, vol. 3, pt. 2, p. 679, figs. 1–4; not *Beyrichia quadrilirata* HALL and WHITFIELD, *1785*, Ohio Geol. Survey, Paleontology, vol. 2, p. 105, pl. 4, figs. 6–7.

Valves small to medium, similar. Outline oval to subquadrangular; dorsal margin slightly sinuous because of projections of ridges; retral swing commonly obvious. Free margins of valve with broad, flat border having angular thickened margin; ridges four in number forming anterior and posterior pair and including nearly square area within the border; outer anterior ridge paralleling margin from near anterior end of dorsal margin to ventral margin along which it continues as ventral ridge to its continuation in outer posterior ridge; inner anterior ridge forming chord of the arc of the outer ridge, trending slightly posterior to ventral, the two defining an elliptical loop; this inner ridge bifurcates in ventral part, there being a broad relatively depressed ridge that trends ventroposteriorly from its middle to the middle of the ventral marginal ridge. Outer posterior ridge quite continuous with ventral ridge, commonly with slight angle at base of inner posterior ridge; outer ridge terminating abruptly adjacent to posterior end of dorsal margin; inner posterior ridge short, not approaching dorsal margin, bulbous at dorsal end. Often there are evident on relatively broad ridges, narrow linear elevations; commonly there is another of these narrow ridges within the outer posterior ridge, forming a double ridge; many specimens have from two to five projections normal to the marginal ridge on its posteroventral; if there be five, the anterior-most is commonly about opposite inner anterior ridge, others extending at intervals to dorsal posterior margin; in a few large specimens these are quite obscured by a frill extending from posterior ridge, occasionally reaching beyond contact.

Holotype, No. 27485 C. (base Ion member, Decorah formation, sec. 13, Glenwood tp., Winneshiek County, Iowa): length, 0.83 mm.; width, 0.55 mm.; thickness one valve, 0.24 mm. Paratypes, Nos. 27546 C., 27523 C. (same). No. 9–907 I. (Ion member, Decorah formation, Iowa): length, 0.90 mm.; width, 0.61 mm.; thickness one valve, 0.28 mm. No. 27526 C. (same). No. 27529 C. (Hull formation, Healey Falls).

Uncommon in Hull formation, Healey Falls, Ontario; common to abundant in Guttenberg and Ion members of Decorah formation, uncommon in Spechts Ferry member, Iowa and Minnesota; common in Glenburnie member of Chaumont formation, Ontario.

It seems inadvisable to separate the varieties with and without posteroventral projections, for when many specimens are examined from a single faunule, all intermediate forms are found; commonly the most of the specimens lack marginal projections or have them poorly developed.

The species is quite similar to the Cincinnatian species, *T. quadrilirata* (Hall and Whitfield) and *T. simplex* Ulrich; a distinctive feature is that the anterior ridges are invariably connected dorsally to enclose a loop; the fine elevations are also not described as occurring in those species.

TETRADELLA ULRICHI Kay, n. name

Plate 45, figures 16–19

Tetradella lunatifera ULRICH, *1894*, Geol. Minnesota, vol. 3, pt. 2, p. 680, pl. 46, figs. 12–14, text figs. 51*a–b;* not *Strepula lunatifera* ULRICH, *1889*, Canada Geol. Survey, Contr. Micro-Paleontology, pt. 2, p. 56, pl. 9, figs. 14–14*b*. (Cincinnatian Stony Mountain formation, Stony Mountain, Manitoba.)

Valves small, equal. Outline subellip-

tical to subquadrangular; dorsal margin nearly straight, ridges projecting slightly if at all; free margins regularly curved, anterior most convex; retral swing obvious. Free margins with relatively broad flat border, highest at periphery, where it rises abruptly from contact. Within are six ridges, outer anterior and inner posterior as in *T. ellipsilira;* inner anterior ridges subequal and parallel, joined by loop at dorsal end, which is connected with outer anterior ridge; included area between ridges variable. Inner half of outer posterior ridge a chord of outer half, which is the more dorsally extended; these ridges are distinctly separated from more bulbous inner posterior ridge. Though commonly lacking any sort of posteroventral marginal projections, these are frequently developed as in the holotype.

Holotype No. 27487 C. (Hull formation, Healey Falls): length, 0.87 mm.; width, 0.58 mm.; thickness one valve, 0.24 mm. Paratypes, No. 9–908 I. (Ion member, Decorah formation, Iowa): length, 0.84 mm.; width, 0.525 mm.; thickness one valve, 0.23 mm. No. 27528 C. (Sherman Fall formation, near Gamebridge, Victoria County, Ont.), No. 27527 C. (same).

Not as common as last in Hull formation, Healey Falls, Ontario; frequent in Guttenberg and Ion members, Decorah formation, Iowa; common in Sherman Fall formation at Gamebridge, Ontario.

This species has a resemblance to *T. lunatifera*, but that species is illustrated as having the ridges much less continuous.

Genus CERATOPSIS Ulrich, 1894

Genoholotype *Beyrichia chambersi* MILLER, *1874*, Cincinnati Quart. Jour. Sci., vol. 1, p. 234, fig. 27. (Cincinnatian Eden group, Cincinnati, Ohio.) *Ceratopsis chambersi* (Miller) ULRICH, *1894*, Geol. Minnesota, vol. 3, pt. 2, p. 676 [figures of *C. quadrifida* (Jones)].

Ceratella ULRICH, *1890*, Cincinnati Soc. Nat. Hist., Jour., vol. 13, p. 113, *nomen nudum.*

Ceratopsis ULRICH, *1894*, Geol. Minnesota, vol. 3, pt. 2, p. 675.—ULRICH and BASSLER, *1909*, U. S. Nat. Mus., Proc., vol. 35, p. 308; *1923*, Maryland Geol. Survey, Silurian, p. 311.

Valves medium in size, equal. Outline commonly sharply truncated short oval. Four ventrally continuous ridges having distinctive process rising from posterior ridge with serrate spine, or mushroom-like form. Contact plane; border with thickening or frill.

Ordovician.

CERATOPSIS QUADRIFIDA (Jones), 1891

Plate 44, figure 27

Beyrichia quadrifida JONES, *1891*, Canada Geol. Survey, Contr. Micro-Paleontology, pt. 3, p. 66, pl. 66, figs. 9*a–b*. (Basal Trenton, Lorette Falls on St. Charles River, P. Q.).

Ceratopsis quadrifida ULRICH and BASSLER, *1909*, U. S. Nat. Mus., Proc., vol. 35, pl. 39, figs. 21–22.

Ceratopsis chambersi ULRICH, *1894*, Geol. Minnesota, vol. 3, pt. 2, pl. 46, figs. 19–22. —ULRICH and BASSLER, *1909*, U. S. Nat. Mus., Proc., vol. 35, pl. 39, figs. 13–16; *1923*, Maryland Geol. Survey, Silurian, p. 310, fig. 5. (In each of the latter cases, the specimen illustrated is of Trenton age and is misidentified.)

Valves medium in size, similar. Outline oval with dorsal truncation; dorsal margin straight, quite as long as greatest length of valve, which is dorsal to mid-height; free margins very regularly curved; retral swing obvious. Free margins of valve with narrow border, edge of which is rounded at anterior but extends into narrow flange or frill along ventral and posterior margins. Surface of valves with three rounded ridges and conspicuous posterior spine; greatest thickness of valve anteroventral to middle. Anterior ridge low and broad at dorsal margin, paralleling anterior margin and continuing as rounded ventral ridge to base of spine on posterior margin, highest above plane of valves at mid-venter. Separated by shallow, oblique sinus from second lobe, which extends anterodorsally from middle of ventral ridge to dorsal margin; second ridge higher, more narrow than anterior one; third ridge short, not approaching dorsal margin, separated from second, to which

it is parallel, by rather deep and broad sinus; commonly with node at its dorsal end; typically the node is somewhat isolated from ventral part of ridge. Spine shaped like sector of cone, extending from its base dorsal to middle of posterior margin in anterodorsal direction at angle to plane of valves; projecting considerably beyond dorsal margin; its inner margin bearing many fine oblique grooves that make the margin serrate. Contact plane.

Plesiotype No. 27542 C. (Sherman Fall formation near Gamebridge, Victoria County, Ontario): length, 1.20 mm.; width, 0.67 mm.; thickness one valve, 0.39 mm. Plesiotype No. 27568 C. (Ion member, Decorah formation, Iowa).

Frequent in Sherman Fall formation in Canadian National Railway cut a mile north of Gamebridge, Ontario; type from lower Trenton at Lorrette Falls, St. Charles River, near Quebec, P. Q. Frequent in lower Ion member of Decorah formation at type locality in Fairview Township, Allamakee County, Iowa. Uncommon in Hull formation at Healey Falls, Ontario.

The specimens from the Sherman Fall formation are very similar to the genotype. The Ion specimens seem relatively shorter; the third lobe is commonly nodose at its dorsal extremity, and the spine seems more attenuate and shorter.

Genus BASSLERATIA Kay, n. gen.

Genoholotype *B. typa* Kay, next described.

Valves small, equal. Outline subelliptical, dorsally truncated; dorsal margin straight, often with slight projection at posterior end. Marginal ridge quite entire; similar ridge, more elevated, within it on free margins; within which are other ridges and nodes. Contact obscured by overhanging margins, plane, without thickening.

Ordovician.

This genus is quite distinct from any that has been described. In the number of its ridges, rather than in their arrangement, it resembles *Strepula*, *Steusloffia* and *Drepanella*. In addition to the species here described, there is a species in the Glenburnie member of the Chaumont formation in Ontario. The generic name is in recognition of the contributions to Ordovician paleontology and to the knowledge of lower Paleozoic Ostracoda made by Prof. R. S. Bassler of the United States National Museum.

BASSLERATIA TYPA Kay, n. sp.
Plate 46, figures 1–12

Valves small, equal. Outline elliptical to oval, dorsally truncated; ends subequal, anterior the more convex if either; retral swing rarely discernible; dorsal margin straight, three-fifths length of valve, with dorsal projection at posterior end. Marginal ridge entire, dorsal extremities projecting slightly beyond it; within this ridge on free margins is similar but more elevated ridge; posterior limb linear, extending posteroventrally from dorsal margin, curving sharply to middle of venter, and continuing within marginal ridge to anterior of dorsal margin; anterolateral so elevated as to be highest point on valve, within a ridge extends anteroventrally from anterior and ventral to middle of dorsal margin, continuing within second ridge to middle of posterior half of valve, where it ends abruptly, or curves sharply to anterodorsal to circular or elliptical node posterodorsal to middle of valve; this node commonly isolated; ridge of greater radius of curvature than anterior limb of last ridge joining middle of dorsal marginal ridge to that ridge just posteroventral to center of valve; third ridge often deflected dorsally to meet it.

Contact of valves mostly obscured by overhanging margins that in well preserved specimens bear elongate pits paralleling the contact planes; hinge line straight, about three-fifths length of valve, deflected dorsally at posterior; extremities angular; cardinal area meeting plane of valves at about seventy degree angle; border overhanging contact

on anterior and ventral; retral swing obvious in outline of contact. Interior of valve having stout partition extending from dorsal just posterior to middle, defining pits on either side of it, the anterior being the larger. Contact plane, with very fine linear elevation presumably acting as tongue, though valves seem exactly equal, neither having groove; no thickening at contact.

Holotype No. 27512 C. (low Hull formation, Healey Falls): length, 0.86 mm.; width, 0.54 mm.; thickness one valve, 0.30 mm. Paratypes, No. 27476 C. (same): length, 0.95 mm.; width, 0.545 mm.; thickness one valve, 0.28 mm. 27530 C. (same): length, 0.92 mm.; width, 0.55 mm.; thickness one valve, 0.28 mm. 9–911 I. (same): length, 0.78 mm.; width, 0.48 mm.; thickness one valve, 0.23 mm. 6246 GSC. (same). 971 T. (same), 27531 C. (same).

Paratypes, No. 27477 C. (Ion member, Decorah formation, Iowa): length, 0.94 mm.; width, 0.57 mm.; thickness one valve, 0.39 mm. 27532 C. (same): length, 0.91 mm.; width, 0.57 mm; thickness one valve, 0.34 mm.

Genus BELLORNATIA Kay, n. gen.

Genoholotype *B. tricollis* Kay, next described.

Genus based on two very similar species, distinct and unique and of wide geographic distribution. It is most similar to the last described genus, but has only a superficial resemblance to *Bassleratia*.

Ordovician, species known in uppermost Black River (Chaumont formation, Glenburnie member) and lower Trenton (Hull formation and Ion member, Decorah formation).

BELLORNATIA TRICOLLIS Kay, n. sp.
Plate 44, figures 22–26

Valves small, equal. Outline elliptical, dorsal border straight, short, slightly projecting at posterior end; ends subequal, regularly curved, retral swing not obvious. Border entire, forming marginal ridge; slight sulcus near middle of dorsal margin. Intermarginal ridge leaves anterodorsal margin and curves toward middle of anterior half of valve, turning sharply toward posterior end of hinge line from middle of posteroventral of valve; this ridge with continuous dorsal marginal ridge forming a posteriorly truncated ellipse, anterior end of which is marginal and elevated. Within are three nodes, anterior and posterior of which are equidistant from hinge line, median one being just ventral to dorsal margin anterior to its mid-length and dorsal to other two; anterior node largest, dorsal the smallest. Anterodorsal portion of intermarginal ridge superimposed on somewhat concealed swellings or nodes. Contact plane; obscured dorsally by extended dorsal margin, particularly at anterior; hinge line straight; cardinal angles slightly obtuse.

Holotype No. 27480 C. (Ion member, Decorah formation, Iowa): length, 0.63 mm.; width, 0.38 mm.; thickness one valve, 0.20 mm. Paratype No. 6254 GSC., incomplete, (low Hull formation, Healey Falls, Ont.), 27540 C. (same), 27541 C. (same).

Uncommon in low Hull formation, Healey Falls, Ontario, and in Ion member, Decorah formation, Iowa. A similar species is rare in Glenburnie shale, Chaumont formation in Ontario.

Genus RAYMONDATIA Kay, n. gen.

Genoholotype *R. goniglypta* Kay, next described.

Genus based on single species that is not closely similar to any species of another genus. The generic name is in recognition of the contributions of Prof. P. E. Raymond to Trenton stratigraphy.

RAYMONDATIA GONIGLYPTA Kay, n. sp.
Plate 45, figures 7–9

Valves very small, similar. Outline rectangular, posterior width a little greater than that of anterior. Border rising abruptly from margin, forming complete marginal ridge; posterior thicker than

anterior and marginal ridge overhanging contact so as to give very concave profile; interior surface of valve depressed but for two distinct ridges, the anterior of which trends ventrally or anteroventrally from middle third of dorsal margin to center of anterior half of valve, then turns abruptly toward anterior, not reaching anterior border; ridge thus formed commonly with right or slightly obtuse angle. Second ridge posterior to middle of valve and bulbous, extending from dorsal margin to little below midheight; depressed, inconspicuous, Y-shaped ridge connects anteroventral part of second ridge, angle of first and middle of venter. Plane contact; valves evidently equal.

Holotype No. 27484 C. (base Ion member, Decorah formation, sec. 13, Glenwood tp., Winneshiek County, Iowa): length, 0.51 mm.; width, 0.30 mm.; thickness one valve, 0.19 mm. Paratypes, No. 6250 GSC. (low Hull formation, Healey Falls): incomplete. 82287 US. (Ion member, Decorah formation, Iowa): length, 0.71 mm.; width, 0.38 mm.; thickness one valve, 0.21 mm. 9–909 I. (base Ion member, Decorah formation, Iowa): length, 0.49 mm.; width, 0.27 mm.; thickness one valve, 0.16 mm.

Rare to frequent in Guttenberg and Ion members, Decorah formation, Iowa; rather rare in Hull formation, Healey Falls, Ontario.

A similar if not identical species occurs in the middle Platteville formation in northeastern Iowa. The Ontario and Iowa specimens of the species are identical. This species has no obvious relationship to any described species.

SUMMARY

The species of ostracodes occurring in faunules from the lower part of the Hull formation in Ontario are with very few exceptions also present in faunu es from the Ion member of the Decorah formation in northeastern Iowa. Among the species common to the two formations are a few that seem of particular value as guide fossils because of their having distinctive characters, occurring in abundance in both regions, and not having been recognized in subjacent and superjacent formations, from which enough faunules have been studied to make it seem that good control has been established. The similarity of the faunules in Ontario and Iowa supports the correlation of the upper Decorah with the lower Hull, and confirms the classification of the Ion member as of lower Trenton age.

Of the species described, *Cytheropsis rugosus* Jones, has been placed in a new genus, *Punctaparchites;* and in addition to the definition of the new genera *Hallatia, Thomasatia, Bassleratia, Bellornatia* and *Raymondatia,* the following new species have been described: *Punctaparchites ovatus, Halliella linepunctata, H. magnapuncta, Hallatia healeyensis, H. particylindrica, Thomasatia falcicosta, Tetradella ellipsilira, T. ulrichi, Bassleratia typa, Bellornatia tricollis, Raymondatia goniglypta.*

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SOME NOTES ON THE GENUS *HELICOLEPIDINA* TOBLER[1]

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ABSTRACT

The genus and existing literature are briefly reviewed and notes are given on the known species. This is followed by a detailed description of *Helicolepidina polygyralis* Barker, and some remarks on the relationships of the genus.

The name *Helicolepidina* was proposed by Tobler in 1922 (13)[2] for a new subgenus of *Lepidocyclina* Gümbel, the description being based on forms from the Jackson formation of San Fernando, Trinidad, and from the Rio San Pedro, Western Venezuela.

The principal feature of the new form was its spirality and Tobler points out that as *Lepidocyclina* possesses a certain degree of spirality and is considered to be derived from spiral ancestors there is no reason to consider *Helicolepidina* as a separate genus. He prefers to regard the development of the spiral a direct inheritance from *Arnaudiella* which has been put forward as the ancestral form of the Orbitoididae.

Very shortly after Tobler's account of the new subgenus, Douvillé added some notes on its structure and relationships. He (4) doubts the relationship with *Lepidocyclina* and suggests that the characters as shown by a transverse section show more affinities with *Heterostegina* than with the Orbitoididae. The difference between the shape of the median chambers in the two groups is compared to that existing between *Lepidocyclina* and *Discocyclina*.

In another article (3) he suggests the existence of marked similarity to *Spiroclypeus*, basing his comparison principally on the spiral nature of the equatorial layer as opposed to the cyclic or annular nature of that of the true Orbitoid. In 1924 he carried this idea still further and ascribed *Helicolepidina* definitely to the genus *Spiroclypeus*, an opinion with which Vaughan (17, p. 802) concurred.

In 1926 Vaughan recorded *Helicolepidina* from two new localities and expressed his opinion that the form possessed generic significance and was not related to *Spiroclypeus* as hitherto believed (18, p. 534; 19, p. 1854). This view is adhered to in the account of the family Orbitoididae (by Vaughan) in *The Foraminifera, Their Classification and Economic Use* by J. A. Cushman (20, p. 337 and p. 354).

[1] The writer is indebted to the Bataafsche Petroleum Maatschappij for permission to publish these notes.

[2] Numbers in parentheses refer to the Bibliography at the end of the paper.

In 1928 (6, p. 60) Galloway gave a brief and very complete description of *Helicolepidina* as a genus in the subfamily Orbitoidinae Prever, and discussed the phylogenetic relations of the genus.

DESCRIPTION OF SPECIES

Genus HELICOLEPIDINA Tobler, 1922

Genoholotype: *Lepidocyclina* (*Helicolepidina*) *spiralis* TOBLER, Eclogae Geologicae Helvetiae, vol. 17, p. 380, text figs. 1–3, *1922*.

The following description is that given by Galloway with one or two minor additions:

Test discoidal, planispiral; whorls few, rapidly widening, each whorl embracing to the umbos and composed of numerous median and lateral chambers; the median layer as seen in transverse section is similar to that of the Orbitoids generally, except that the spiral of larger chambers causes a break in the layer, with alar prolongations as seen in *Spiroclypeus*. Median chambers vary from arcuate to hexagonal in shape and are very variable in size and arrangement; foramina are present at the anterior and posterior sides of each chamber and appear to be single and not in pairs or threes as in *Lepidocyclina;* lateral chambers as in *Lepidocyclina*, arranged in tiers of four to eight chambers with pillars between the tiers; walls of the lateral chambers thick and conspicuously perforate; surface strongly papillate; microspheric nucleoconch planispiral; megalospheric nucleoconch bilocular, composed of a spherical chamber followed by a smaller, hemispherical chamber, and these followed by smaller arcuate chambers arranged in a spiral. Diameter up to 4.0 mm.

So far as is known the genus is confined to the tropical and subtropical regions of the New World, where it is locally abundant in rocks of upper Eocene age. As was mentioned earlier it was first discovered in Trinidad and Venezuela; in 1926 it was recorded from Ecuador (18) and from Mexico (19); in 1927 Doctor Tobler discovered it in material from Peru (15).

In each case the age was considered to be upper Eocene and the form appeared to have a very definite stratigraphic value. Examination of a collection of larger foraminifera from Peru has tended to cause doubt as to the lower limit of its range (16) but the apparent early appearance of the genus in this case may very well be due to large scale repetition in the succession, the presence of which has been suspected from other evidence. Furthermore the lack of a definite correlation with other areas makes consideration of the range of *Helicolepidina* in the area in question very difficult.

HELICOLEPIDINA SPIRALIS Tobler

Plate 47, figures 1–4; Text figure 1*a*, *c*

Helicolepidina spiralis TOBLER (13), *1922*, p. 343, 345, figs. 1–3; TOBLER (14), *1922*, pp. 380–384; DOUVILLÉ, H. (3), *1923*, p. 375–376, figs. 3, 4; DOUVILLÉ, H. (4), *1923*, pp. 566–569; figs. 1, 2; VAUGHAN, T. W. (17), *1924*, p. 802; VAUGHAN, T. W. (18), *1926*, p. 834; VAUGHAN, T. W. (19), *1926*, p. 1854; HARRIS, G. D. (9), *1926*, p. 104, pl. 18, figs. 4, 5; HODSON, H. K. (10), *1926*, p. 6; TOBLER, A. (15), *1927*, p. 415–22; NUTTALL, W. L. F. (12), *1928*, p. 105, pl. 8, fig. 4; VLERK V. DER (8), *1932*, p. 109, pl. 13, figs. 11–13; BARKER, R. W. (22), *1932*, p. 309, pl. 22, fig. 6; TODD, J. U. and BARKER, R. W. (16), *1932*, p. 532, pl. 11, figs. 3, 4; RUTTEN, M. G., and VERMUNT, L. W. J. (12*b*), *1932*, p. 238; PIJPERS, P. J. (12*a*) *1933*, p. 54.

Since the generic description already quoted was composed principally when the genus was monotypic there is little to add in a description of the species *H. spiralis*. The main specific character, in addition to measurements which are given in the table on page 349, is the length of the spiral of larger chambers, which in this species extends through one and one-quarter whorls or, rarely, one and one-half whorls.

The microspheric form will be discussed under the heading "Trimorphism" but the following description published by Todd and the present writer is quoted to make the account more complete:

"In the microspheric form there is a small spherical initial chamber followed by six chambers in the first spiral. The second spiral has a thick wall and contains seven chambers . . ." (16, p. 532, pl. 40, fig. 3, text fig. 5).

HELICOLEPIDINA SPIRALIS TENUIS Hodson

Helicolepidina spiralis tenuis HODSON, H. K. (10), *1926*, pp. 6, 7, pl. 1, figs. 11–12.

This appears to be merely a thin variety of *Helicolepidina spiralis* with other characters practically the same as for that species. It is unfortunate that there is no figure of an equatorial section in the original description as there is no indication in the account as to the degree of spirality.

HELICOLEPIDINA AUGUST-TOBLERI Berry

Text figure 1*d*

Helicolepidina august-tobleri BERRY, WILLARD (2), *1932*, p. 8, text figs. 1 and 7.

The only important difference between this species and *H. spiralis* would appear from the description to lie in the number of chambers in the so-called "primary spiral." Berry describes his species as possessing eight such chambers including in this total one of the cells of the bilocular nucleoconch, this is shown in a reproduction of the original figure (figure 1*d*). A careful examination of Tobler's original description showed that no mention was made in the text of the number of the spiral chambers in the "primary spiral," reference being made

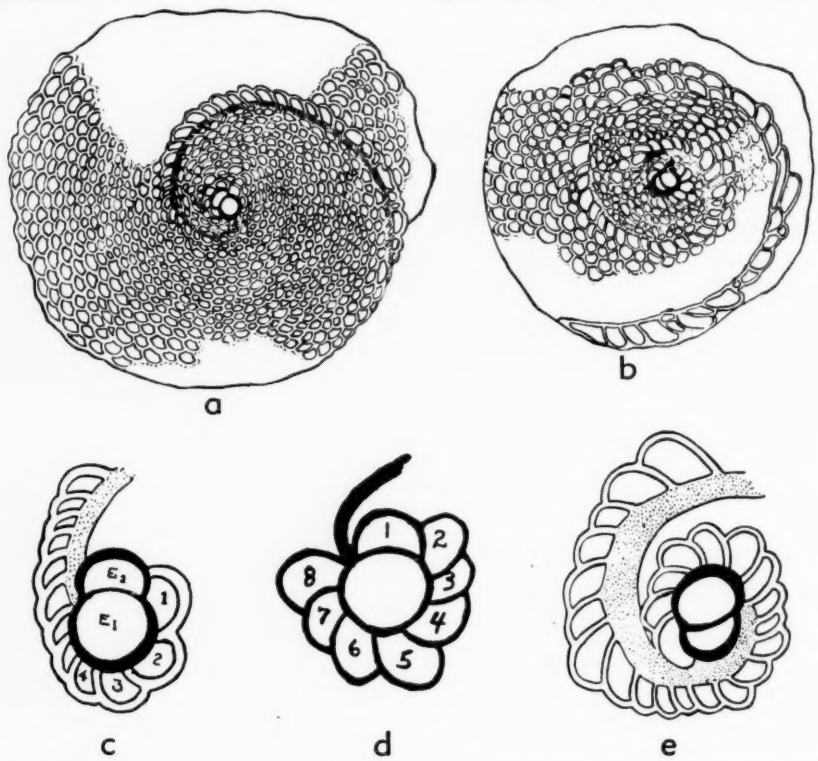

FIG. 1.—*a*, *c*, *Helicolepidina spiralis* Tobler. *a*, Diagrammatic equatorial section, ×17. *c*, Drawing of the embryonic apparatus, ×68 (reconstructed from Tobler's original figure). *b*, *e*, *Helicolepidina polygyralis* Barker. *b*, Diagrammatic equatorial section, ×22. *e*, Embryonic apparatus, ×65. *d*, *Helicolepidina august-tobleri* Willard Berry, embryonic apparatus, ×68 approx. (After Berry's original figure.)

to the figure (a reconstructed diagram of which is shown on figure 1*c*) in which a bilocular embryonic apparatus is followed by seven "primary" chambers of which the first four are numbered. A comparison of these figures of the embryonic apparatus and the remarks and measurements in the table (p. 349) are brought forward in favor of putting *H. august-tobleri* in the synonymy of *H. spiralis* Tobler.

As further evidence it may be pointed out that the author had the opportunity to examine large numbers of specimens of *Helicolepidina* from various localities in northwest Peru and found no specimens which could not be identified with *H. spiralis*.

HELICOLEPIDINA POLYGYRALIS Barker

Plate 47, figures 5–11; Text figure 1*b*, *e*

Helicolepidina polygyralis BARKER, R. WRIGHT (22), *1932*, p. 309, pl. 22, fig. 5, text fig. 4.

The discovery of further topotype material of this species renders it possible to amplify the original description and to give figures of the external appearance and of a transverse section.

Test small, globosely lenticular, with a sharply keeled periphery. Outline oval to circular; the surface ornamented with fine granules near the periphery and with strongly developed papillae over the center of the test. These papillae, which are shown by transverse sections to be the ends of pillars, vary from 100μ–180μ in diameter and are sufficiently prominent to serve as a means of distinction from the other orbitoids which occur with this species.

Measurements of seventeen specimens gave an average diameter of 1.9 mm. with an average thickness of 1.0 mm. These measurements, however, included several very small specimens, and, excluding these, we get the more representative figures: diameter 2.0 mm., thickness 1.1 mm., the respective ranges being 1.5 mm.–2.4 mm. (diameter) and 0.9 mm.–1.25 mm. (thickness). The ratio of diameter to thickness is thus about 1.8/1.

Equatorial sections show the test to consist of three whorls, with seven to nine "primary" spiral chambers following a bilocular nucleoconch with a diameter (including cell walls) of 150μ–180μ.

Transverse sections show the median layer to be very irregular, an average height being 60μ–80μ. The lateral chambers, of which there are usually seven in a tier over the center of the test, are about 60μ in height with walls 40μ thick. Pillars are irregularly developed with an average thickness at the surface of 110μ.

TRIMORPHISM

In the original description of the genus (14) Tobler refers to the probable dimorphism of *Helicolepidina spiralis* as follows:

> Specimens occur which have most of the characters of *H. spiralis* and which show the radial arrangement of the interlocular skeleton in the equatorial layer very beautifully. They are however microspheric and lack the spiral chambers. At the best there is only a slight indication of spiral arrangement in the center.

In subsequent accounts we find no reference to dimorphism until 1928 when Galloway (6, p. 60) describes the microspheric embryo as "a spherical chamber, followed by curved chambers as in *Camerina*."

A different type of microspheric form was figured by the present writer in 1932 (22, pl. 22, fig. 2) in ignorance of the form described by Tobler. Later in the same year examination of material from northwest Peru yielded the typical *H. spiralis* and a microspheric form which agreed with Tobler's description. This was described and figured (16, p. 532, Pl. 40, fig. 3, text fig. 5) no reference being made to the form found in Ecuador. While sectioning material from the Rio San Pedro, Venezuela, a specimen was found which resembled the microspheric form from Ecuador. In size the same as the megalospheric specimens accompanying it this section showed the usual spiral

of one and one-quarter whorls of larger chambers commencing from a microspheric embryonic apparatus resembling that found in *Lepidocyclina*. This is shown in the plate (Pl. 47, figs. 3, 4) with specimens of the megalospheric form and the other microspheric form for comparison.

Since the specimen from Ecuador differs from the new microspheric form from Venezuela chiefly in the greater length of the spiral which is visible for two and one-half whorls it seems justifiable to consider it as the microspheric form of *H. polygyralis* with which it occurs.

Hence it appears that *H. polygyralis* shows one microspheric form and one megalospheric, the latter being the more abundant. *H. spiralis*, on the other hand, shows the startling combination of one megalospheric form with two quite distinct microspheric forms. If this is the case then we are undoubtedly dealing with "Trimorphism" but of a type which has not previously been observed so far as the writer is aware.

Since at present there is only a single example of each of the coiled microspheric forms it is not possible to work out any theory of the possible relationships, but it is hoped that examination of more material will throw further light on the problem. It is evident that the microspheric form is spiral and it remains to be proved that the non-spiral form discovered by Tobler is actually *Helicolepidina*. If this should be shown to be the case then the position of the genus in the family Orbitoididae may be regarded as fairly secure; if, on the other hand, the only microspheric form is spiral then there still remains the possibility of the genus belonging in the Cycloclypeidae.

Since writing the foregoing, attention has been drawn to a paper by P. J. Pijpers (12*a*) in which the same difficulties were encountered in the study of *Helicolepidina*. Two microspheric forms were examined and the following possibilities were put forward by Pijpers (12*a*, p. 54):

1. The first form (i.e. showing feeble spirality in the center) is the microspheric form of *H. spiralis* as is supposed by Tobler. Then the second form is the microspheric form of another new species of *Helicolepidina*.
2. The second form (i.e. with well developed spirality) is the microspheric form of *H. spiralis*. Then it was not found by Tobler and his microspheric specimens were microspheric forms of another *Lepidocyclina* with spiral arrangement in the center as it was found by Douvillé, Bull. Soc. géol. de France, vol. 6, p. 601, 1906) and Cushman (U. S. Geol. Survey, Prof. Paper 125-D, pl. 34, fig. 4, 1920.)
3. Neither of the two forms represent the microspheric form of *H. spiralis*.
4. Both microspheric forms belong to *H. spiralis*.

The age is quoted as upper Eocene, from the locality southwest of Seroe Montagne (W. Bonaire). The two forms, according to Pijpers, range up to 7.7 mm. and 7.2 mm. in diameter respectively.

As may be gathered from the discussion, the writer inclines rather towards the view that both forms belong to *H. spiralis*, both from structural considerations and from the discovery of the two forms with *H. spiralis* in several localities, including two not mentioned in the preceding pages, namely upper Eocene, Curacao (12*b*, p. 534), and upper Eocene, Bonaire (12*a*, p. 54). If such be

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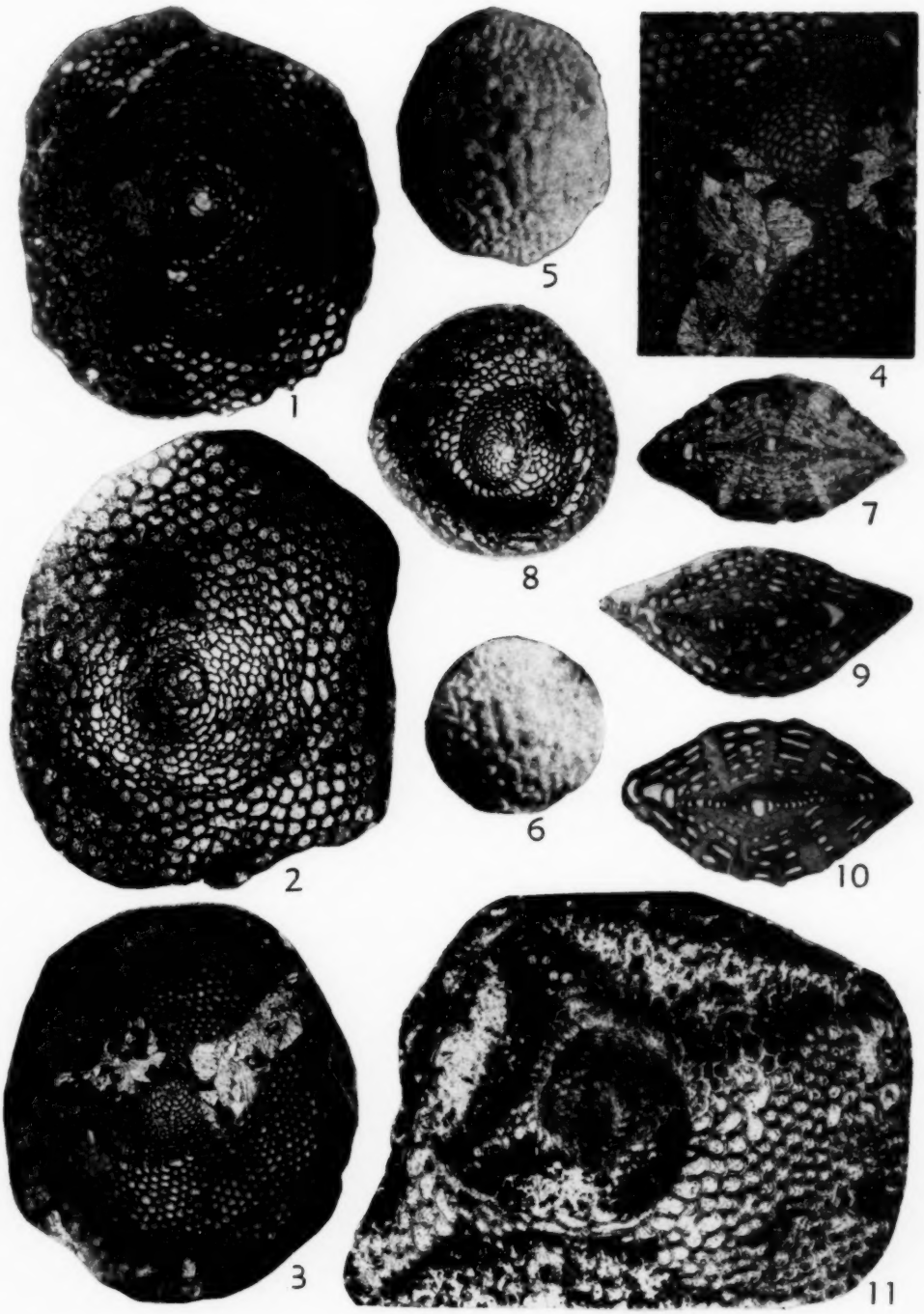
EXPLANATION OF PLATE 47

FIGS. 1–4—*Helicolepidina spiralis* Tobler. 1, Equatorial section, ×17. (Specimen from Trinidad). 2, Microspheric form, equatorial section, ×29. (Specimen from northwest Peru). 3, 4, Microspheric form, equatorial section, 3, ×15; 4, ×23. (p. 345)

5–10—*Helicolepidina polygyralis* Barker. 5, 6, Topotype specimens, ×16. (Ancon Point, Ecuador). 7, Transverse section, ×20. Topotype material from Equador. 8, Equatorial section, ×17. Holotype. 9, 10, Transverse sections, ×20. Topotype material. (p. 347)

11—*Helicolepidina polygyralis* Barker (?), microspheric form, equatorial section, ×26. (p. 347)



Barker, Tertiary Foraminifera

UNIV. OF MICH.

accepted then it may be suggested that the form showing feeble spirality is the more primitive, this being in favor of close relationship with *Lepidocyclina*.

RELATIONSHIPS

The planispiral nature of the test immediately suggests relationship with the Camerinidae and Spiroclypeidae, a resemblance which is further strengthened by the formation of lateral chambers by prolongation and division of the alar walls as in *Spiroclypeus*.

The presence of an undoubted median layer with lateral chambers rules out the Camerinidae, leaving the Spiroclypeidae and the Orbitoididae as possible alternatives. Since the former shows an equatorial layer consisting of chambers subdivided into chamberlets and in *Helicolepidina* we have numerous simple hexagonal to arcuate chambers, relationship with the Spiroclypeidae seems improbable. Careful examination of thin sections and experiments with Hofker's method of balsam impregnation failed to reveal any sign of a canal system, a further point against inclusion in the Spiroclypeidae. Taking into account the shape of the chambers, the general appearance of the test both from the exterior and in thin section, and the probable absence of a canal system it seems almost certain that this genus is correctly placed in the Orbitoididae.

Galloway wishes to make *Helicolepidina* the ancestral form of the Orbitoididae in spite of the fact that it does not appear until the Eocene and possesses a very limited vertical and geographical distribution. It seems somewhat unreasonable to consider an Eocene form as

TABLE SHOWING MEASUREMENTS OF THE VARIOUS SPECIES OF HELICOLEPIDINA

	H. spiralis Tobler	*H. spiralis tenuis* Hodson	*H. augusttobleri* Willard Berry	*H. polygyralis* Barker
Diameter	Up to 4.0 mm.	2.0–4.0 mm.	3.74 mm.	1.6–2.4 mm.
Ratio: Diameter to thickness	2.5:1	4:1	3.74:1	1.8:1
Pillars	Present, thick	Present, slight	Present, thick	Present, variable
Number of whorls	1.25–1.5	?	1.25	2.5–3
Number of chambers in "primary spiral" excluding the embryonic apparatus	7	?	7	7–9
Diameter of initial embryonic chamber	90μ–120μ	152μ	156μ	90μ–100μ
Thickness of wall of nucleoconch	18μ	?	?	20μ–30μ
Length of embryonic apparatus	200μ	?	200μ	150μ
Thickness of pillars	? 200μ (from fig.)	small	566.8μ	80μ–150μ
Number of tiers of lateral chambers	5–7	? 4	?	6–7
Diameter of median chambers	?	170μ app.	?	35μ–110μ

the ancestor of a large and diverse group of Cretaceous genera, which according to the stratigraphic evidence available became extinct before the beginning of the Tertiary epoch.

It is suggested that a possible lineage may be found through *Polylepidina* to some form such as *Orbitocyclina*, the spirality observed in these genera reaching a maximum in *Helicolepidina*. As was indicated by Vaughan in 1928 (20, p. 336) it is possible that *Helicolepidina* later gave rise to *Miogypsina*, though this as yet is purely hypothetical.

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APPENDIX

(?) Helicolepidina vichayalensis (Rutten)

Lepidocyclina (?Isolepidina) vichayalensis Rutten, *1928*, Koninck. Akad. Wetensch., Amsterdam, Proc., vol. 31, no. 9, p. 15, fig. 24 *f–k*, *n–p*, pl. ii 25–26.

Lepidocyclina (Polylepidina) vichayalensis Todd and Barker, *1932*, Geol. Mag., vol. 69, pp. 532–3, text fig. 4, pl. xl 5–6.

Dr. Wayland Vaughan, to whom the writer wishes to express his gratitude, has suggested that for the sake of completeness *Helicolepidina vichayalensis* (Rutten) should be included in the pres-

ent account. In an unpublished communication Doctor Vaughan makes the following remark regarding *H. vichayalensis*:—

> A little more than a year ago I recognized that this species should be referred to *Helicolepidina* . . .

He further states that Doctor Rutten had already reached the same conclusion, though on account of other work he had never published this view.

Doctor Rutten in his original description draws attention to the similarity to *Helicolepidina*, a fact which was further emphasized by J. U. Todd and the writer a year ago.

While examining a series of specimens from Peru, certain forms were eventually determined as *L. vichayalensis* Rutten. At first it was believed that these specimens should be referred to *Helicolepidina* but this view was eventually abandoned for the following reasons:

(a) Transverse sections failed to reveal the spiral method of growth, with the alar prolongation of the median septal walls usually seen in *Helicolepidina*.
(b) The thick wall bounding the spiral of larger chambers in *Helicolepidina* (seen in equatorial sections) was not observed.
(c) The extreme shortness of the spiral of larger chambers appeared to the writer to represent part of the embryonic apparatus rather than a part of the median layer.

On these grounds it was decided that the species could best be referred to the subgenus *Polylepidina* Vaughan. In view of Doctor Vaughan and Doctor Rutten's opinion that the species should be referred to *Helicolepidina*, the author proposes to leave the matter open until more detailed work can be carried out.

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ADDITIONAL NOTES ON DIATOMS FROM THE CRETACEOUS OF CALIFORNIA

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In 1927, I published a paper on the Cretaceous diatoms of California[1] in which thirty-five species were recorded from the type locality of the Moreno shale, Moreno Gulch in the Panoche Hills, Fresno County, California. It seemed desirable to limit that paper strictly to the type locality because of the generally recognized Cretaceous age of the formation. Some measure of doubt had been attached to previous records of diatoms as far back as that epoch and it was hoped that no such uncertainty would be associated with the paper presented.

A few miles south of the type locality but along the strike of the rocks, there is an excellent exposure of Moreno shale from which beautifully preserved siliceous organisms may be extracted by the usual cleaning processes. Mr. C. C. Church and I have made collections there several times and a set of the diatoms has been mounted for individual study. For the most part, the species are the same as those recorded from Moreno Gulch, but, as always happens in such investigations, a few additional forms were found. Some of these are of much interest because they further confirm the closeness of these beds in age to those of the Simbirsk area of central Russia.

The particular locality at which the collection was made is numbered 1144 in the records of the California Academy of Sciences. The exposure is in an unnamed gulch (the fourth northwest of Panoche Creek) along the east flank of Panoche Hills in sec. 6, T. 15 S., R. 12 E., M.D.M., Fresno County, California. The best exposed diatomite is about 100 feet below the base of the conspicuous Eocene sandstone, the intervening zone being composed largely of clay shales.

A few macrofossils have been found in the Moreno shale but they do not help much in the assignment of the formation to its proper place in the Cretaceous system. Ammonites are rare and poorly preserved. A small bacculite and a hamite are the most common but they are not very diagnostic. An *Acila* and an *Arca*-like form have been collected in a few cases and fragments of *Inoceramus* are not uncommon. Among the foraminifera a *Siphogenerina*-like form (probably *ewaldi* Karsten) is extremely abundant in the upper part but is usually represented by molds in the shales. In the limestone concretions,

[1] Hanna, G. D., Cretaceous diatoms from California: *Calif. Acad. Sci., Occ. Papers*, no. 13, pp. 1–46, 5 pls., Sept. 17, 1927.

the tests are filled with calcite and their extraction is difficult.

The shales definitely overlie approximately 30,000 feet of other Cretaceous sediments, much of which is later than Chico. From the upper part of this, Cushman and Church[2] have described a collection of foraminifera, which, however, differ considerably from those of the Moreno.

DESCRIPTION OF SPECIES

AULACODISCUS ARCHANGELSKIANUS Witt

Plate 48, figure 7

Aulacodiscus archangelskianus, WITT, *1886*, Verh. Russ. Kais. Mineral Gesell. St. Petersburg, ser. 2, vol. 22, p. 154, pl. 6, fig. 11, Archangelsk, Russia.—SCHMIDT, *1886*, Atlas Diat., pl. 101, figs. 7–11.

Aulacodiscus tschestnovii PANTOCSEK, *1893*, Beit. z. Kennt. Foss. Bacill. Ungarns, pt. 3, pl. 6, fig. 93; text, *1905*, p. 18; Kusnetzk, Russia.

Aulacodiscus pugnalus HANNA, *1927*, Calif. Acad. Sci., Occ. Paper, no. 13, p. 14, pl. 1, figs. 6, 7.

The receipt of some material from the Cretaceous of Russia has permitted a direct comparison of what appears to be Witt and Pantocsek's species with *pugnalus* and I now believe them to be the same. They and Schmidt have illustrated only five spined forms and I have found only four spined ones in the California Cretaceous; with no other important structural difference this cannot be considered adequate ground for separation. My reference in the description of *A. pugnalus* to *A. septus* was confused unintentionally with *A. archangelskianus; A. septus* is a very different species and has not yet been found in our deposit. *A. archangelskianus* is common at Loc. 1144, (C.A.S.). Panoche Hills, Fresno County, California; Moreno, Upper Cretaceous.

HAYNALDIA STRIGILLATA Witt

Plate 48, figures 1, 2

Coscinodiscus strigillatus WITT in Schmidt, *1889*, Atlas Diat., pl. 138, fig. 20. "Archangelsk."

Haynaldia antiqua PANTOCSEK, *1889*, Beit. Kennt. Foss. Bacill. Ungarns, pt. 2, pp. 24, 120. "Bory," Hungary.

Not *Haynaldella antiqua* PANTOCSEK, *1893*, Beit. Kennt. Foss. Bacill. Ungarns, pt. 3, pl. 32, fig. 459; text, *1905*, p. 57. "Bory" and "Elesd," Hungary.

Haynaldiella antiqua PANTOCSEK, *1896*, Van Heurck, Treat. Diat., English Ed., p. 536, fig. 281.

There is some confusion in the name of this diatom. Evidently Witt and Pantocsek discovered it independently and Witt's name was published first. Pantocsek's original spelling of the genus name was *Haynaldia;* no explanation has been given for the changes which have appeared. In his original description of the genus and species he referred to the figure in Schmidt's Atlas but gave no illustration of his own. Therefore, strictly speaking, the name "*antiqua*" should be considered a synonym of *strigillata*. When Pantocsek published a figure of his Hungarian diatom a few years later he either illustrated a quite different species or made a very poor drawing. After considerable experience in the use of his publications, I believe the figures are trustworthy in most cases. Therefore, it seems desirable to reserve the name *antiqua* for the Hungarian (Tertiary) diatom and use *strigillata* for the Cretaceous form. The former has a series of radiating dots which are not wavy in the slightest degree and do not reach the margin, leaving a broad hyaline zone; (these characters are obvious from Pantocsek's figure). From the available information the form might be placed in some of the groups of pelagic discoid distoms such as *Ethmodiscus*. Until additional material from Hungary can be studied the form may best be allowed to remain as *H. antiqua*.

[2] Cushman, J. A., and Church, C. C., Some Upper Cretaceous foraminifera from near Coalinga, California: *Calif. Acad. Sci., Proc.*, (4) vol. 18, no. 16, pp. 497–530, pls. 36–41, 1929.

The diatom figured by Schmidt is a very remarkable form with its radially arranged wavy lines. I have found what appears to be the same, common at Loc. 1144 (C.A.S.), Panoche Hills, Fresno County, California; age Moreno, Upper Cretaceous.

BENETORUS FANTASMUS Hanna

Plate 48, figure 8

Benetorus fantasmus HANNA, *1927*, Calif. Acad. Sci., Occ. Paper, no. 13, p. 16, pl. 1, figs. 9, 10.

Specimens are fairly rare at Loc. 1144 and it is difficult to find one which is unbroken.

CHASEA, Hanna, n. gen.

Frustule composed of two parts, an outer bicornate portion and an inner endocystoid-like form; the valves on one side are slightly longer than those on the other; markings consist of a few very irregular lines or wrinkles in the silica. Type: *Chasea bicornis* Hanna, n. sp.

CHASEA BICORNIS Hanna, n. sp.

Plate 48, figures 12–16

In a general way this diatom resembles a *Chaetoceros* with an endocyst; the outer portion is hyaline and contains a central projecting ridge across the long axis of the oval; at each end of the ridge there is an obtuse horn shaped spine; the "endocyst" consists of a flat plate with a dome-shaped protuberance in the center; the horn on one side is longer than that on the other indicating that growth of the chain was in the form of a curve as in *Eucampia*.

Syntypes Nos. 3365–3369 (Calif. Acad. Sci.) from sec. 6, T. 15. S., R. 12 E., M.D.M., Panoche Hills, Fresno County California; Moreno, Upper Cretaceous.

This diatom agrees with *Chaetoceros* sufficiently well so that it can be included in the same family with that genus. It is abundant at Loc. 1144. The genus is named for Dr. H. H. Chase, the indefatiguable compiler of catalogues of species of diatoms.

EXPLANATION OF PLATE 48

FIGS. 1, 2—*Haynaldia strigillata* (Witt). 1, Plesiotype No. 3371 (Calif. Acad. Sci.). Diameter, 0.120 mm. 2, Plesiotype No. 3372 (Calif. Acad. Sci.). Diameter, 0.1068 mm. (p. 353)

3–5—*Rattrayella churchi* Hanna, n. sp. 3, Holotype No. 3374 (Calif. Acad. Sci.). Diameter, 0.1160 mm. 4, Paratype No. 3375 (Calif. Acad. Sci.). Diameter, 0.0378 mm. 5, Paratype No. 3376 (Calif. Acad. Sci.). Diameter, 0.050 mm. (p. 355)

6—*Micrampulla parvula* Hanna. Plesiotype No. 3373 (Calif. Acad. Sci.). Length, 0.040 mm., diameter, 0.0149 mm. (p. 355)

7—*Aulacodiscus archangelskianus* Witt. Plesiotype No. 3363 (Calif. Acad. Sci.). Diameter, 0.0940 mm. (p. 353)

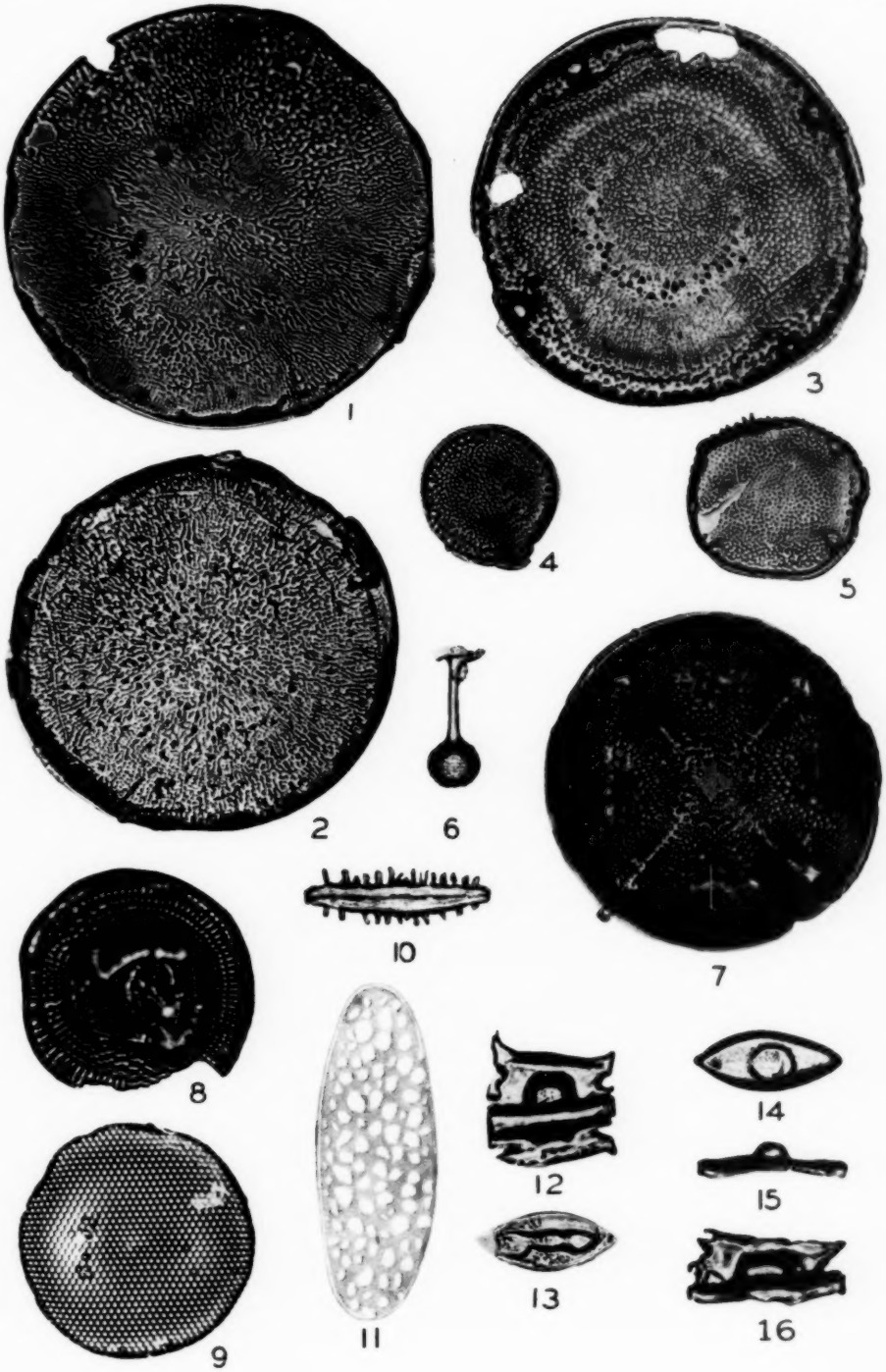
8—*Benetorus fantasmus* Hanna. Plesiotype No. 3364 (Calif. Acad. Sci.). Diameter, 0.0340 mm. (p. 354)

9—*Coscinodiscus lineatus* Ehrenberg. Plesiotype No. 3370 (Calif. Acad. Sci.). Diameter, 0.0965 mm. (p. 355)

10, 11—*Xanthiopyxis granti* Hanna. 10, Plesiotype No. 3377 (Calif. Acad. Sci.). Length, 0.0517 mm. 11, Plesiotype No. 3378 (Calif. Acad. Sci.). Length, 0.1068 mm., width, .0534 mm. (p. 355)

12–16—*Chasea bicornis* Hanna, n. sp. 12, Syntype No. 3365 (Calif. Acad. Sci.). Length, 0.0376 mm. Complete frustule, side view, with endocyst. 13, Syntype No. 3366 (Calif. Acad. Sci.). Width, 0.0185 mm. End view of frustule. 14, Syntype No. 3368 (Calif. Acad. Sci.). Length, 0.0418 mm. Top of "endocyst" form. 15, Syntype No. 3369 (Calif. Acad. Sci.), Length, 0.040 mm. Side view of "endocyst" form. 16, Syntype No. 3367 (Calif. Acad. Sci.). Length, 0.0431 mm. Side view of valve with "endocyst." (p. 354)

All of the diatoms illustrated on this plate are from Calif. Acad. Sci. Loc. 1144, sec. 6, T. 15 S., R. 12 E., M.D.M., Panoche Hills, Fresno County, California, Moreno shale, Upper Cretaceous.



Hanna, Cretaceous diatoms

UNIV. OF MICH.

COSCINODISCUS LINEATUS Ehrenberg

Plate 48, figure 9

Diatoms which do not seem to differ from the usual form of *C. lineatus* are common at Loc. 1144. This is the second species found in the California Cretaceous which has not been separated from living forms.

MICRAMPULLA PARVULA Hanna

Plate 48, figure 6

Micrampulla parvula HANNA, *1927*, Calif. Acad. Sci., Occ. Paper, no. 13, p. 26, pl. 3, fig. 15.

The original figure of this species had the spine broken; one which appears to be practically complete is furnished herewith. The relationship of the diatom appears to be with *Pterotheca* and possibly *Kentrodiscus*.

RATTRAYELLA CHURCHI Hanna, n. sp.

Plate 48, figures 3–5

Valve large circular; border heavy, with four, low, ocelli-like pillars; markings consist of radial rows of fine beads with a few heavy ones interspersed irregularly in a subcentral annular zone. Between the four pillars there is a marginal row of heavy rounded beads.

Holotype No. 3374; paratypes Nos. 3375, 3376, (Calif. Acad. Sci.) from sec. 6, T. 15 S., R. 12 E., M.D.M., Panoche Hills, Fresno County, California; Moreno, Upper Cretaceous.

The species is related to *R. simbirskianus* (Grunow) (Schmidt, Atlas Diat. pl. 125, figs. 18, 19, 1888) and *R. oamaruensis* (Grunow) but the markings are bolder and the border zone is much heavier; moreover, those forms have six or more spines and in most of the figures they alternate, large and small. Those species were described under *Glyphodiscus* but Fricke in the index to Schmidt's Atlas transferred them to *Rattrayella*.

The two paratypes are much smaller than the holotype and show some interesting variations. The one illustrated in figure 4 has only three heavy pillars and they are not equally spaced around the margin. The one shown in figure 5 has four equally-spaced pillars; in both of these there is a marginal row of short spines between the pillars instead of the heavy beads of the holotype. The markings of the disk are essentially the same in all of the specimens but the smaller ones lack the scattered large beads among the rows of fine radial beads. In spite of the differences noted it is believed that all belong to the same species. A similar range in variation is shown in other species of discoid diatoms which show a wide difference in size between the largest and smallest individuals.

The species is named for Mr. C. C. Church, Paleontologist, Associated Oil Company, San Francisco, California.

XANTHIOPYXIS GRANTI Hanna

Plate 48, figures 10, 11

Xanthiopyxis granti HANNA, Calif. Acad. Sci., Occ. Paper, no. 13, p. 39, pl. 5, figs. 13, 14.

Since this is a variable species and the original figures were somewhat defective two additional ones are furnished herewith. The surface of the valve is irregularly spinose and in front view has a maculate appearance. In side view both valves are found to be alike and the species therefore agrees in structure with such forms as *X. umbonatus* and *X. panduriformis*. These species probably are true diatoms and not "endocystoid" forms or "rest spores." The genus *Xanthiopyxis* has sometimes been grouped with such objects along with *Dicladia*, *Periptera*, *Syndendrium*, etc.

BIBLIOGRAPHY AND INDEX TO NEW GENERA AND SPECIES OF FORAMINIFERA FOR THE YEAR 1932

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The following Bibliography includes 308 titles of papers, of which 290 were published during the year 1932 and 18 in the course of the year 1931.

Besides the publications dealing exclusively with foraminifera (description of new forms, morphology, taxonomy, faunal lists, etc.), those in which foraminifera are either only mentioned or used for stratigraphic correlation purposes are also incorporated. These latter are of particular importance for the regional stratigrapher working in comparative and correlative stratigraphy.

To facilitate the use of this Bibliography, a stratigraphic and geographic index is appended, giving the numbers of the titles dealing with each formation or country.

Omitted or overlooked titles, the communication of which would be greatly appreciated by the writer, will be included in the forthcoming bibliography for the year 1933.

The Index to new genera, species, and varieties of foraminifera for the year 1932 following the bibliography contains 1 family, 21 genera, 4 subgenera, 372 species and 94 varieties. Furthermore, about 60 names are listed of species indefinitae (sp. ind.) or of such ones, to which the *nomenclatura aperta* (n. sp. aff.) was applied. One new species, *Nodosaria batschi* Thalmann, n. sp., is proposed.

During the year 1932 six homonyms were erected, namely: **Cristellaria recta** Scheffen (d'Orbigny, 1840); **Dentalina pectinata** Paalzow (Terquem, 1870); **Lagena lanceolata** Paalzow (Herrmann, 1917); **Lepidocyclina delicata** Scheffen (Berry, 1929) (see recommendations to Art. 36 of the Rules of International Nomenclature); **Nodosaria schwageri** Paalzow (Rzehak, 1888); and **Nonion cretaceum** Cushman and Jarvis (Schlumberger, 1899). In accordance with Articles 35 and 36 of the Rules of International Nomenclature, **N. cretaceum** Cushman and Jarvis was changed by the writer to **N. jarvisi** nom. nov. The remaining homonyms should be renamed as soon as possible by their respective authors. According to Art. 20 (and recommendations to it) of the above-cited Rules, specific denominations such as **"subkubinyi"** (see **Cristellaria**), **"postdouvilléi"** and **"postterhaari"** (see **Cycloclypeus**) are not recommended. *Nomina nuda*, or manuscript names in faunal lists, even when published as such, are nonexistent from a nomenclatorial standpoint (see Art. 25 of the Rules) and, therefore, are not listed here.

For previously published specific names, the writer has added, following the author's name, the date (year) of publication (see examples given in Articles 22 and 23 of the Rules). This will facilitate the consultation of the paper in which the species originally was published.

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II. INDEX TO NEW GENERA, SPECIES AND VARIETIES OF FORAMINIFERA ERECTED DURING THE YEAR 1932

Acervulina chipolensis Cushman and Ponton, **76,** 104, pl. 16, figs. 7, 8. Lower Miocene, Florida.

Ammobaculites prostomum Hofker, **146,** 87, text figs. 14, 15. Recent, Mediterranean Sea. [For *Ammobaculites pseudospirale* (Williamson, 1858) in Brady, 1884, and for *A. cassis* (Parker, 1870) in Egger, 1893.]

Ammobaculoides nov. gen., Plummer, **210,** 87. Fam. Trochamminidae. Genotype: *A. navarroensis* Plummer, 1932. Upper Cretaceous, Texas.

——— *navarroensis* Plummer, **210,** 87, text fig. 1. Upper Cretaceous, Texas.

Ammodiscus minutus Paalzow, **205,** 93, pl. 4, figs. 10, 11. Jurassic, Argovian, Germany.

Amphicoryne n. sp. aff. "intermediate specimen with Vaginuline commencement and final nodosarian chamber" Brady, 1884, n. sp. aff. Thalmann, **280,** 304. Recent, Tahiti.

——— n. sp. aff. spec. (?) Brady, 1884, n. sp. aff. Thalmann, **280,** 311. Recent, Fiji.

Amphimorphina sp. (?) Cushman and Ponton, **76,** 75, pl. 11, figs. 4–6. Miocene, Florida.

Amphistegina chipolensis Cushman and Ponton, **76,** 96, pl. 15, fig. 1. Lower Miocene, Florida.

——— *floridana* Cushman and Ponton, **76,** 96, pl. 14, figs. 6, 7. Lower and middle Miocene, Florida.

Angulogerina albatrossi Cushman, **63,** 45, pl. 6, figs. 11, 12. Recent, eastern Pacific.

——— ——— ——— var. *ornata* Cushman, **63,** 45, pl. 6, figs. 13, 14. Recent, eastern Pacific.

——— *carinata* Cushman, 1927, var. *bradyana* Cushman, **63,** 45, pl. 6, figs. 9, 10. Recent, eastern Pacific. [For *Uvigerina angulosa* Brady, 1884, non Williamson, 1858.]

——— *danvillensis* Howe and Wallace, **149,** 56, pl. 12, fig. 2. Upper Eocene, Louisiana.

Annulocibicides nov. gen., Cushman and Ponton, **74,** 1. Fam. Rotaliidae. Lower Miocene, Florida. Genotype: *A. projectus* Cushman and Ponton, 1932.

——— *projectus* Cushman and Ponton, **74,** 2, pl. 1, fig. 1. Lower Miocene, Florida.

Anomalina alazanensis Nuttall, **202,** 31, pl. 8, figs. 5–7. Lower Oligocene, Mexico.

——— *danvillensis* Howe and Wallace, **149,** 76, pl. 14, fig. 2. Upper Eocene, Louisiana.

——— *harperi* Sandidge, **236,** 316, pl. 29, figs. 5, 6 (erroneously figs. 1, 2 in text). Upper Cretaceous, Alabama.

——— *heathensis* Berry, **19,** 31, pl. 2, figs. 14–16. Upper Oligocene, Peru.

——— *mecatepecensis* Nuttall, **202,** 30, pl. 7, figs. 4, 6. Lower Oligocene Mexico.

——— *nonionoides* Parr, **207,** 231, pl. 22, fig. 38. Recent, New South Wales, Australia.

——— n. sp. aff. *Truncatulina grosserugosa* Brady, 1884, (non Gümbel, 1868), n. sp. aff. Thalmann, **280,** 309. Recent, Ascension Island and North Pacific.

——— *umbilicatula* Heron-Allen and Earland, **141,** 426, pl. 14, figs. 40–42. Recent, Falkland Islands.

Amorella nov. gen., Heron-Allen and Earland, **140,** 256. Fam. Astrorhizidae. Recent, South Atlantic. Genotype: *A. sphaerica* Heron-Allen and Earland, 1932.

——— *sphaerica* Heron-Allen and Earland **140,** 257, pl. 2, figs. 4–11. Recent, South Atlantic.

Articulina sagra d'Orbigny, 1839, var. *miocenica* Cushman and Ponton, **76,** 51, pl. 6, figs. 2–4. Lower Miocene, Florida.

Asterigerina miocenica Cushman and Ponton, **76,** 95, pl. 14, fig. 4. Middle Miocene, Florida.

Asterocyclina, see *Discocyclina*.

Asterorbis nov. gen., Vaughan and Cole, **292,** 611. Fam. Orbitoididae. Upper Cretaceous, Mississippi. Genoholotype: *A. rooki* Vaughan and Cole, 1932.

——— *rooki* Vaughan and Cole, **292,** 611, pl. 1, figs. 1–6. Upper Cretaceous, Mississippi.

Bathysiphon minutum Hofker, **146,** 70, text fig. 4. Recent, Mediterranean Sea.

Bigenerina floridana Cushman and Ponton, **76,** 42, pl. 1, figs. 9–12. Miocene, Florida.

——— *ripleyensis* Sandidge, **238,** 268, pl. 41, figs. 4, 5. Upper Cretaceous, Alabama.

——— *suevica* Paalzow, **205,** 95, pl. 4, fig. 20. Jurassic, Argovian, Germany.

Biloculina depressa d'Orbigny, 1826, var. *minuta* Hofker, **146,** 105, text fig. 22. Recent, Gulf of Naples.

Blastammina nov. gen., Eisenack, **109,** 261. Fam. Astrorhizidae. Silurian, Baltic Provinces. Genotype: *B. polymorpha* Eisenack, 1932.

——— *polyedra* Eisenack, **109,** 263, pl. 11, figs. 16, 17, text figs. 5–8. Silurian, Baltic Provinces.

——— *polymorpha* Eisenack, **109,** 261, pl. 11, figs. 11–15, text figs. 1–4. Silurian, Baltic Provinces.

Bolivina cincta Heron-Allen and Earland, **141,** 356, pl. 9, figs. 16–18. Recent, Falkland Islands.

——— *danvillensis* Howe and Wallace, **149,** 56, pl. 11, fig. 8. Upper Eocene, Louisiana.

——— *gracilis* Cushman and Applin, 1926, var. *danvillensis* Howe and Wallace, **149,** 57, pl. 11, fig. 7. Upper Eocene, Louisiana.

——— *malovensis* Heron-Allen and Earland, **141,** 355, pl. 9, figs. 12–15. Recent, Falkland Islands.

——— *ouachitaensis* Howe and Wallace, **149,** 59, pl. 11, fig. 9. Upper Eocene, Louisiana.

——— *paula* Cushman and Cahill, ms., in Cushman and Ponton, **76,** 84, pl. 12, fig.6. Miocene, Florida.

——— *plicatella* Cushman, 1930, var. *mera* Cushman and Ponton, **76,** 82, pl. 12, fig. 4. Middle Miocene, Florida.

——— *qubrada* Berry, **19,** 27, pl. 3, figs. 8, 9. Upper Oligocene, Peru.

——— *subreticulata* Parr, **206,** 12, pl. 1, fig. 21. Recent, Torres Strait. [For *Bolivina reticulata* Brady, 1884, non v. Hantken, 1875].

Bolivinella elegans Parr, **207,** 223. Recent, Bass Strait, Australia. [For *Textularia folium* Parker and Jones, in Brady, 1884.]

Bradyina grandis Liebus, **182,** 168, pl. 10, figs. 19, 20. Lower Carboniferous, Germany.

Bulimina auricula Heron-Allen and Earland, **141,** 351, pl. 9, figs. 1, 2. Recent, Falkland Islands.

——— *bicona* Berry, **19,** 28, pl. 3, figs. 13, 14. Upper Oligocene, Peru.

——— *heathensis* Berry, **19,** 28, pl. 3, figs. 6, 7. Upper Oligocene, Peru.

——— *truncana* Gümbel, 1868, var. *denticulata* Protescu, **216,** 26, pl. 4, fig. 16. Upper Eocene, Roumania.

Buliminella basistriata Cushman and Jarvis, 1929, var. *nuda* Howe and Wallace, **149,** 60, pl. 11, fig. 4. Upper Eocene, Louisiana.

——— *cushmani* Sandidge, **238,** 280, pl. 42 figs. 18, 19. Upper Cretaceous, Alabama.

——— n. sp. aff. *Bulmina elegantissima* var. *seminuda* Brady, 1884 (non d'Orbigny, 1839, non Terquem, 1882) n. sp. aff. Thalmann, **280,** 302. Recent, Bass Strait, Australia.

Bullopora brachypartita Paalzow, **205,** 138, pl. 11, fig. 3. Jurassic, Argovian, Germany.

——— *compacta* Paalzow, **205,** 139, pl. 11, fig. 2. Jurassic, Argovian, Germany.

——— *rugosa* Paalzow, **205,** 139, pl. 10, figs. 2, 3. Jurassic, Argovian, Germany.

——— *waidelichi* Paalzow, **205,** 138, pl. 10, fig. 5. Jurassic, Argovian, Germany.

Calpionella elliptica Cadisch, **38,** 249, text fig. 3; figs. 10, 11, 17, 25, 26. Jurassic, Biancone limestone, southern Switzerland.

——— *oblonga* Cadisch, **38,** 252, text fig. 3, figs. 20, 21. Jurassic, Biancone limestone, southern Switzerland.

Camerina absurda Doornink, **94,** 299, pl. 9, figs. 11–17, text fig. 1. Lower Oligocene, Java.

——— *densa* Doornink, **94,** 295, pl. 8, figs. 1–5. Upper part of middle Eocene, Java.

——— *divina* Doornink, **94,** 299, pl. 9, figs. 5–10. Upper Oligocene, Java.

——— *gerthi* Doornink, **94,** 296, pl. 7, figs. 15–21, text fig. *f*. Probably lower Eocene, Java.

——— *hoogenraadi* Doornink, **94,** 297, pl. 9, figs. 1–4, text figs. *g*, *h*, *i*, *k*. Lower part of upper Eocene, Java.

——— *semiglobula* Doornink, **94,** 292, pl. 7 figs. 1–14, text figs. *d*, *e*. Upper Eocene, Java.

Cancris danvillensis Howe and Wallace, **149,** 67, pl. 13, figs. 4, 5. Upper Eocene, Louisiana.

Carpenteria lobosa Heron-Allen and Earland, **141,** 426, pl. 15, fig. 19. Recent, Falkland, Islands.

——— sp. van Rijsinge, **229,** 53, pl. 4, figs. 20–24. Paleocene, southeastern Holland.

Cassidulina chipolensis Cushman and Ponton, **76,** 98, pl. 15, fig. 2. Lower Miocene, Florida.

——— *crassa* d'Orbigny, 1839, var. *porrecta* Heron-Allen and Earland, **141,** 358, pl. 9, figs. 34–37. Recent, Falkland Islands.

Cibicides danvillensis Howe and Wallace, **149,** 77, pl. 14, fig. 5. Upper Eocene, Louisiana.

——— *mexicana* Nuttall, **202,** 33, pl. 9, figs. 7–9. Lower Oligocene, Mexico.

——— *ouachitaensis* Howe and Wallace, **149,** 78, pl. 14, fig. 6. Upper Eocene, Louisiana.

——— *perlucida* Nuttall, **202,** 33, pl. 8, figs. 10–12. Lower Oligocene, Mexico.

——— *ripleyensis* Sandidge, **235,** 199, pl. 19, figs. 17–19. Upper Cretaceous, Alabama.

Clavulina alazanensis Nuttall, **202,** 8, pl. 2, fig. 10. Lower Oligocene, Mexico.

——— *aspera* Cushman, 1926, var. *whitei* Cushman and Jarvis, **73,** 19, pl. 5, figs. 6–8. Upper Cretaceous, Trinidad. [For *Clavulina trilatera* White, 1928, non Cushman, 1926.]

——— *chitinosa* Cushman and Jarvis, **73,** 20, pl. 5, figs. 9–11. Upper Cretaceous, Trinidad.

——— *plummerae* Sandidge, **238,** 270, pl. 41, figs. 17, 18. Upper Cretaceous, Alabama.

——— *triangularis* Nuttall, **202,** 9, pl. 2, fig. 4. Lower Oligocene, Mexico.

Clavulina ? sp. Wickenden, **304,** 205, pl. 29, fig. 5. Upper Cretaceous, Canada.

Cornuspira denticulata Heron-Allen and Earland, **141,** 323, pl. 7, figs. 6–8. Recent, Falkland Islands.

Cribratina nov. gen. Sample, **234,** 319. Fam. Textulariidae. Cretaceous, Comanchean, Texas. Genotype: *Nodosaria texana* Conrad, 1857.

Cristellaria calcar (Linné, 1758) var. *alazanensis* Nuttall, **202,** 9, pl. 1, fig. 9. Lower Oligocene, Mexico.

——— *dix* Berry, **19,** 28, pl. 3, figs. 3, 4. Upper Oligocene, Peru.

——— *heathensis* Berry, **19,** 29, pl. 3, figs. 1, 2. Upper Oligocene, Peru.
——— *pustulosa* Protescu, **216,** 23, pl. 3, figs. 1, 2, 7, 8. Upper Eocene, Roumania.
——— *recta* Scheffen, **247,** 197, pl. figs. 4, 5. Miocene, Java. (The species name is already preoccupied by d'Orbigny, 1840.]
——— *subkubinyii* Nuttall, **202,** 11, pl. 1, fig. 16. Lower Oligocene, Mexico.
——— *sublituus* Nuttall, **202,** 11, pl. 1, figs. 13, 14. Lower Oligocene, Mexico.
——— *subpapillosa* Nuttall, **202,** 12, pl. 1, fig. 12. Lower Oligocene, Mexico.
——— *tenuissima* Heron-Allen and Earland, **141,** 389, pl. 12, figs. 16–20. Recent, Falkland Islands.
Cyclammina elegans Cushman and Jarvis, **73,** 13, pl. 3, fig. 6. Upper Cretaceous, Trinidad.
Cycloclypeus eidae Tan, **272,** 50, pl. 5, fig. 6; pl. 12, figs. 2, 3; pl. 13, fig. 2. Miocene, Aquintanian and lower Burdigalian, East Borneo, Java, Sumatra.
——— *dodecimseptus* Tan, 170, pl. 13, fig. 6.
——— *ennekaidekaseptus* Tan, **272,** 170, pl. 13, fig. 4.
——— *heneikosiseptus* Tan, **272,** 170, pl. 13, fig. 5.
——— *heptakaidekaseptus* Tan, **272,** 170, pl. 13, fig. 1.
——— *indopacificus* Tan, **272,** p. 64. (No species typica designated by the author.)
——— ——— Tan, 1932, var. *douvillei* Tan, **272,** 68, pl. 15, fig. 8; pl. 20, figs. 3, 5, 6; pl. 21, figs. 2–6. Probably upper Miocene of Rembang, Java.
——— ——— ——— ——— var. *indopacifica* Tan, **272,** 66, pl. 23, fig. 2; cf. also pl. 15, fig. 7; pl. 18, fig. 3; pl. 19, fig. 1; pl. 22, fig. 10. Upper Burdigalian (Miocene) to Holocene in Dutch East Indies.
——— ——— ——— ——— var. *terhaari* Tan, **272,** 71, pl. 16, fig. 1, 3, 4; pl. 17, fig. 4; pl. 18, figs. 1, 4, 9; pl. 19, figs. 2–5, 8, 11; pl. 22, figs. 4, 6. Upper Tertiary, Dutch East Indies.
——— ——— ——— ——— var. *vandervlerki* Tan, **272,** 67, pl. 17, figs. 5, 6; pl. 18, figs. 5, 6. Upper Miocene, East Borneo.
——— *inornatus* Tan, **272,** 85. (No species typica mentioned by the author.)
——— ——— Tan, 1932, var. *inornata* Tan, **272,** 85, pl. 15, fig. 6; pl. 16, figs. 2, 6, 7; pl. 17, figs. 2, 9; pl. 19, fig. 6. Upper Tertiary of Tegal, Java.
——— ——— ——— ——— var. *tenuis* Tan, **272,** 87, pl. 20, figs. 1, 2, 7. Upper Tertiary, Java.
——— *koolhoveni* Tan, **272,** 41, pl. 4, figs. 1, 5, 6; pl. 5, figs. 3, 7; pl. 7, fig. 2; pl. 8, figs. 1, 2. Lower Oligocene, South Bantam, Java.
——— ——— *triginduoseptus* Tan, **272,** 156, pl. 6, fig. 3.
——— ——— *trigintaseptus* Tan, **272,** 156, pl. 6, fig. 1.
——— ——— *vigintiseptiseptus* Tan, **272,** 158, pl. 7, fig. 1.
——— *oppenoorthi* Tan, **272,** 43, pl. 5, figs. 1, 2; pl. 6, fig. 2; pl. 8, fig. 3; pl. 10, fig. 4; pl. 11, figs. 1, 3, 4; pl. 12, figs. 1, 4, 5. Rupelian and Chattian, Java.
——— ——— *hepteikosiseptus* Tan, **272,** 160, pl. 8, fig. 4.
——— ——— *tetreikosiseptus* Tan, **272,** 164, pl. 10, figs. 1, 2.
——— ——— *triakontaseptus* Tan, **272,** 162, pl. 9, fig. 2.
——— ——— *undevigintiseptus* Tan, **272,** 164, pl. 10, fig. 3.
——— ——— *vigintuniseptus* Tan, **272,** 162, pl. 9, fig. 1.
——— *posteidae* Tan, **272,** 59, pl. 13, fig. 3; pl. 14, figs. 1, 2; pl. 15, figs. 1–4; pl. 18, figs. 2, 7; pl. 22, figs. 3, 4, 8. Miocene, Aquitanian and lower Burdigalian, East Borneo.
——— ——— *dodekaseptus* Tan, **272,** 172, pl. 14, figs. 4–6; p. 174, pl. 15, figs. 1–3.
——— ——— *hexaseptus* Tan, **272,** 166, pl. 11, fig. 2; p. 172, pl. 14, figs. 7, 8; p. 174, pl. 15, figs. 3, 4.
——— ———*pentekaidoseptus* Tan, **272,** 172, pl. 14, fig. 3.
——— *postindopacificus* Tan, **272,** 64. (No species typica designated by the author.)
——— ——— Tan, 1932, var. *postdouvillei* Tan, **272,** 68, pl. 15, fig. 8; pl. 20, figs. 3, 5, 6; pl. 21, figs. 2–6. Probably upper Miocene of Rembang, Java.
——— ——— ——— ——— var. *postindopacifica* Tan, **272,** 66, pl. 23, fig. 1; pl. 18, fig. 3; pl. 19, fig. 1; pl. 22, fig. 10. Cf. also pl. 15, fig. 7. Miocene, upper Burdingalian, to Holocene in the Dutch East Indies.

——— *postindopacificus* Tan, 1932, var. *postterhaari* Tan, **272,** 71, pl. 16, figs. 3, 5; pl. 17, fig. 4; pl. 18, figs. 1, 4, 9; pl. 19, figs. 2–5, 8; pl. 22, figs. 5, 6. Upper Tertiary of Tegal, Java.

——— ——— —— —— var. *tenuitesta* Tan, **272,** 73, pl. 5, fig. 4; pl. 20, fig. 4; pl. 22, figs. 1, 2, 9; pl. 23, figs. 5, 8. Upper Tertiary, Java.

——— *postinornatus* Tan, **272,** 89, pl. 23, figs. 3, 4. Upper Tertiary, Java.

——— *reticulatus* Caudri, **39,** 193, pl. 1, figs. 7–8; pl. 3, figs. 1–4. Upper Tertiary, Java.

Cycloclypeus (*Katacycloclypeus*) *posttransiens* Tan, **272,** 83. (No fig. given.)

——— ——— *transiens* Tan, **272,** 119. (No. fig. given.)

——— (*Radiocycloclypeus*) *radiatus* Tan, **272,** 94, pl. 17, figs. 3, 7; pl. 19, fig. 7; pl. 22, fig. 7. Upper Tertiary, Java.

——— ——— *stellatus* Tan, **272,** 92, pl. 17, figs. 1, 8; pl. 18, fig. 8; pl. 19, figs. 9, 10; pl. 21, fig. 1. Upper Tertiary, Dutch East Indies.

Cyclologulina miocenica Cushman and Ponton, **74,** 3, pl. 1, figs. 3, 4. Miocene, Florida.

Darbyella nov. gen., Howe and Wallace, **149,** 23. Fam. Lagenidae. Upper Eocene, Louisiana. Genoholotype: *D. danvillensis* Howe and Wallace, 1932.

——— *danvillensis* Howe and Wallace, **149,** 24, pl. 4, figs. 1, 2. Upper Eocene, Louisiana.

Dendrophyra jurassica Paalzow, **205,** 90, pl. 4, fig. 16. Jurassic, Argovian, Germany.

Dentalina cushmani Paalzow, **205,** 112, pl. 7, figs. 18, 22. Jurassic, Argovian, Germany.

———*digitata* Paalzow, **205,** 115, pl. 8, figs. 2, 3. Jurassic, Argovian, Germany.

——— *frankonica* Paalzow, **205,** 118, pl. 8, fig. 17. Jurassic, Argovian, Germany.

——— *mexicana* (Cushman, 1925) var. *danvillensis* Howe and Wallace, **149,** 26, pl. 6, fig. 4. Upper Eocene, Louisiana.

——— *pectinata* Paalzow, **205,** 116, pl. 8, fig. 6. Jurassic, Argovian, Germany. [This species name is preoccupied by Terquem, 1870.]

——— *pinnigera* Sandidge, **238,** 274, pl. 42, figs. 11, 12. Upper Cretaceous, Alabama.

——— *pupa* Paalzow, **205,** 112, pl. 7, figs. 13, 14. Jurassic, Argovian, Germany. (This species must not be confused with *Nodosaria pupa* Karrer, 1878.)

——— sp. (A) Howe and Wallace, **149,** 26, pl. 6, fig. 4. Upper Eocene, Louisiana.

——— sp. (B) Howe and Wallace, **149,** 26, pl. 6, fig. 1. Upper Eocene, Louisiana.

——— sp. (C) Howe and Wallace, **149,** 27, pl. 6, fig. 3. Upper Eocene, Louisiana.

——— sp. (?) Cushman and Ponton, **75,** 56, pl. 7, fig. 17. Eocene, Alabama.

——— sp. (?) Cushman and Ponton, **76,** 61, pl. 9, figs. 1, 2. Middle Miocene, Florida.

——— sp. (?) Cushman and Ponton, **76,** 61, pl. 9, figs. 3, 4. Lower Miocene, Florida.

——— *spinata* Paalzow, **205,** 119, pl. 8, fig. 24. Jurassic, Argovian, Germany.

Dimorphina danvillensis Howe and Wallace, **149,** 44, pl. 8, fig. 1. Upper Eocene, Louisiana.

Discammina nov. gen., Lacroix, **177,** 2. Fam. Ammodiscidae. Recent, Mediterranean Sea. Genotype: *D. fallax* Lacroix, 1932.

——— *fallax* Lacroix, **177,** 2, text figs. *a–e.* Recent, off Monaco, Mediterranean Sea.

Discocyclina anconensis Barker, **16,** 303, pl. 21, figs. 1, 4; text fig. 1. Middle Eocene, Ecuador.

——— *blumenthali* Gorter and van der Vlerk, **128,** 111, pl. 16, figs. 2–4. Upper Eocene, Venezuela.

——— *euaensis* Whipple, **299,** 84, pl. 22, figs. 3–7; text fig. 6. Eocene, Eua, Tonga.

——— *novaezelandiae* Chapman, **43,** 485, pl. 62, figs. 7, 10. Middle Eocene, New Zealand.

——— *restinensis* Todd and Barker, **285,** 529, pl. 39, figs. 3–5, 7. Eocene, Peru.

——— *sheppardi* Barker, **16,** 304, pl. 21, fig. 2; text fig. 2. Middle Eocene, Ecuador.

——— sp. indet. Whipple, **299,** 84, pl. 22, figs. 1–2. Eocene, Eua, Tonga.

——— *speighti* Chapman, **43,** 485, pl. 61, figs. 1c, 4b; pl. 62, fig. 6b. Middle Eocene, New Zealand.

——— (*Asterocyclina*) *maracaibensis* Gorter and van der Vlerk, **128,** 113, pl. 17, figs. 1–3. Upper Eocene, Venezuela.

——— ——— sp. Whipple, **299,** 86, pl. 21, fig. 1. Eocene, Eua, Tonga.

Discorbis australis Parr, **207,** 227, pl. 22, fig. 31. Recent, Victoria. [For *Discorbina valvulata* Brady, 1884, non *Rosalina valvulata* d'Orbigny, 1839.]

——— *candeiana* (d'Orbigny, 1839) var. *bullata* Cushman and Ponton, **76,** 89, pl. 13, fig. 5. Lower Miocene, Florida. [For *Truncatulina cora* Cushman, 1922.]

——— *collinsi* Parr, **207,** 230, pl. 22, fig. 33. Recent, Victoria, Australia.

——— *coronata* Heron-Allen and Earland, **147,** 416, pl. 14, figs. 25–30. Recent, Falkland Islands.

——— *farishi* Cushman and Ellisor, **72,** 43, pl. 6, fig. 6. Upper Eocene, Louisiana.

——— *heathensis* Berry, **19,** 30, pl. 2, figs. 1–3. Upper Oligocene, Peru.

——— *malovensis* Heron-Allen and Earland, **141,** 415, pl. 14, figs. 22–24. Recent, Falkland Islands.

——— *plana* Heron-Allen and Earland, **141,** 413, pl. 14, figs. 9–12. Recent, Falkland Islands.

——— *tricamerata* Heron-Allen and Earland, **141,** 413, pl. 14, figs. 13–16. Recent, Falkland Islands.

——— *vesicularis* (Lamarck, 1804) var. *acervulinoides* Parr, **207,** 229, pl. 21, fig. 30. Recent, South Australia.

——— *williamsoni* Chapman and Parr, ms., in Parr, **207,** 226, pl. 21, fig. 25. Recent, Australia. [For *Rotalina nitida* Williamson, 1858, non Reuss, 1846.]

Dyocibicides danvillensis Howe and Wallace, **149,** 78, pl. 15, figs. 1–2. Upper Eocene, Louisiana.

——— n. sp. aff. *Truncatulina variabilis* Brady, 1884, non d'Orbigny, 1839; n. sp. aff. Thalmann, **280,** 309. Recent, New Zealand.

Ellipsoglandulina carseyae Silvestri, **261,** 383, pl. 2, fig. 12. Cretaceous, Albian, Texas.

Ellipsonodosaria sp. Howe and Wallace, **149,** 67, pl. 9, fig. 9. Upper Eocene, Louisiana.

Elphidium macellum (Fichtel and Moll, 1798) var. *tumidocamerale* Bogdanowicz, **28,** 11, pl. 1, fig. 2; text figs. 9, 10. Sarmatian, Kubansky region, Caucasus.

——— *magellanicum* Heron-Allen and Earland, **141,** 440, pl. 16, figs. 26–28. Recent, Falkland Islands.

——— *regina* (d'Orbigny, 1846) var. *caucasicum* Bogdanowicz, **28,** pl. 1, figs. 11–14; text figs. 23–26. Sarmatian, Kubansky region, Caucasus.

——— sp. No. 1 Bogdanowicz, **28,** 22, text figs. 33, 34. Sarmatian, Kubansky region, Caucasus.

——— sp. Howe and Wallace, **149,** 50, pl. 9, fig. 6. Upper Eocene, Louisiana.

Eponides ouachitaensis Howe and Wallace, **149,** 69, pl. 13, fig. 8. Upper Eocene, Louisiana.

——— sp. van Rijsinge, **229,** 53, pl. 4, fig. 11. Paleocene, southeastern Holland.

Fasciolites celebensis Bakx, **12,** 288, pl. 1, figs. 9, 10. Eocene, Dutch East Indies. [For *Alveolina* cf. *oblonga* d'Orb. in Douvillé, 1921.]

Fischerina involuta Cushman, **69,** 76, pl. 17, fig. 6. Recent, tropical Pacific.

Flabellammina clava Alexander and Smith, **4,** 304, pl. 45, figs. 12, 13. Upper Cretaceous, Texas.

——— *longiuscula* Alexander and Smith, **4,** 303, pl. 45, figs. 13, 16; pl. 46, fig. 1. Lower Cretaceous, Texas.

——— *magna* Alexander and Smith, **4,** 306, pl. 46, figs. 10, 11. Upper Cretaceous, Texas.

——— *rugosa* Alexander and Smith, **4,** 302, pl. 45, figs. 6–9, text figs. 1, 2*b*, 2*c*. Cretaceous, Texas.

——— *washitensis* Alexander and Smith, **4,** 303, pl. 45, figs. 10, 11; text fig. 2*a*. Lower Cretaceous, Texas.

Flabellina semiornata Nuttall, **202,** 17, pl. 4, figs. 2, 3. Lower Oligocene, Mexico.

Flintina floridana Cushman and Ponton, **76,** 55, pl. 7, figs. 3–6. Upper Miocene, Florida.

Frankeina acutocarinata Alexander and Smith, **4,** 307, pl. 47, figs. 1, 6. Lower Cretaceous, Texas.

——— *cushmani* Alexander and Smith, **4,** 309, pl. 47, figs. 10, 11. Upper Cretaceous, Texas. [For *Haplophragmium murchisoni* Beissel, 1891, non Reuss, 1854.]

——— *incerta* Alexander and Smith, **4,** 308, pl. 47, fig. 4. Lower Cretaceous, Texas.

——— *insolita* Alexander and Smith, **4,** 308, pl. 47, figs. 2, 3. Lower Cretaceous, Texas.

——— *rugosissima* Alexander and Smith, **4,** 311, pl. 47, figs. 12, 13. Upper Cretaceous, Texas.

——— *wenoensis* Alexander and Smith, **4,** 309, pl. 47, fig. 5. Lower Cretaceous, Texas.

Frondicularia alazanensis Nuttall, **202,** 17, pl.

3, fig. 15; pl. 4, fig. 1. Lower Oligocene, Mexico.
——— *berryi* Sandidge, **236,** 314, pl. 29, figs. 3, 4. Upper Cretaceous, Alabama.
——— *carinthiaca* (Liebus, 1927) var. *carinata* Jedlitschka, **156,** 10, pl. fig. 16. Miocene, Czechoslovakia.
——— *rehamnae* Russo, **232,** 133, text figs. 1, iii, iv; 2, iii, iv; 3, iii; 5, iii. Upper Cretaceous, Maestrichtian, Marocco.
——— *trispiculata* Sandidge, **238,** 278, pl. 42, fig. 23. Upper Cretaceous, Alabama.
Fusulina meeki (Dunbar and Condra, 1927) var. *similis* Galloway and White, ms., in White, **300,** 30, pl. 1, figs. 13–15. Pennsylvanian, Texas.
Fusulinella sp. Liebus, **182,** 169, pl. 10, fig. 30. Lower Carboniferous, Germany.
Gallowayina nov. gen., Ellis, **110,** 1. Fam. Orbitoididae. Upper Eocene, Cuba. Genotype: *G. browni* Ellis, 1932.
——— *browni* Ellis, **110,** 4, text figs. 1–7. Upper Eocene, Cuba.
Gaudryina atlantica (Bailey, 1851) var. *asperita* Cushman and Barbat, **71,** 37, pl. 5, fig. 13. Miocene, California.
——— *bearpawensis* Wickenden, **302,** 88, pl. 1, fig. 7. Upper Cretaceous, Canada.
——— *colei* Nuttall, **202,** 7, pl. 2, fig. 6. Lower Oligocene, Mexico. [For *G. hantkeni* Nuttall, 1928, non Lörenthey, 1909.]
——— *cylindrica* Nuttall, **202,** 7, pl. 2, fig. 7. Lower Oligocene, Mexico.
——— *hastata* Parr, **207,** 219, pl. 22, fig. 40. Recent, Victoria, Australia.
——— *lobatula* Cushman and Barbat, **71,** 38, pl. 5, fig. 12. Miocene, California.
——— *navarroana* Cushman, **64,** 98, pl. 11, figs. 15, 16. Upper Cretaceous, Texas.
——— *painoides* Wickenden, **302,** 88, pl. 1, fig. 3. Upper Cretaceous, Canada.
——— *rudita* Sandidge, **237,** 342, pl. 31, figs. 19, 20. Upper Cretaceous, Alabama.
——— *rugulosa* Cushman, **69,** 15, pl. 4, fig. 1. Recent, tropical Pacific.
——— sp. (?) Cushman, **69,** 15, pl. 4, fig. 2. Recent, tropical Pacific.
Gaudryinella pseudoserrata Cushman, **64,** 99, pl. 11, figs. 20, 21. Upper Cretaceous, Texas.
Globigerina danvillensis Howe and Wallace, **149,** 74, pl. 10, fig. 9. Upper Eocene, Louisiana.
——— *ouachitaensis* Howe and Wallace, **149,** 74, pl. 10, fig. 7. Upper Eocene, Louisiana.
——— sp. (A) Howe and Wallace, **149,** 75, pl. 10, fig. 8. Upper Eocene, Louisiana.
——— sp. (B) Howe and Wallace, **149,** 75, pl. 10, fig. 5. Upper Eocene, Louisiana.
Globorotalia palmarealensis Nuttall, **202,** 30, pl. 7, figs. 1–3. Lower Oligocene, Mexico.
——— *wilcoxensis* Cushman and Ponton, **75,** 71, pl. 9, fig. 10. Eocene, Alabama.
Globotruncana convexa Sandidge, **238,** 285, pl. 44, figs. 9–11. Upper Cretaceous, Alabama.
Globulina n. sp. aff. *Polymorphina rotundata* Brady, 1884, non Bornemann, 1855; n. sp. aff. Thalmann, **280,** 306. Recent, Pacific.
Glomospira bulbifera Paalzow, **205,** 93, pl. 4, fig. 18. Jurassic, Argovian, Germany.
Gordiospira nov. gen., Heron-Allen and Earland, **140,** 254. Fam. Miliolidae. Recent, South Atlantic. Genotype: *G. fragilis* Heron-Allen and Earland, 1932.
——— *fragilis* Heron-Allen and Earland, **140,** 254, pl. 1, figs. 1–6. Recent, South Georgia, South Atlantic.
Gümbelina sp. (?) Cushman and Jarvis, **73,** 42, pl. 13, fig. 1. Upper Cretaceous, Trinidad.
——— sp. Howe and Wallace, **149,** 53, pl. 9, fig. 8. Upper Eocene, Louisiana.
——— *wilcoxensis* Cushman and Ponton, **75,** 66, pl. 7, figs. 16, 17. Eocene, Alabama.
Guttulina sp. Howe and Wallace, **149,** 49, pl. 7, fig. 2. Upper Eocene, Louisiana.
——— *wilcoxensis* Cushman and Ponton, **75,** 60, pl. 8, figs. 1, 2. Eocene, Alabama.
Gyroidina alabamensis Sandidge, **238,** 283, pl. 43, figs. 13–15. Upper Cretaceous, Alabama.
——— *danvillensis* Howe and Wallace, **149,** 69, pl. 13, fig. 3. Upper Eocene, Louisiana.
Hantkenina mccordi Howe and Wallace, **149,** 55, pl. 10, fig. 1. Upper Eocene, Louisiana.
——— (*Schackoina*) *senoniensis* Thalmann, **279,** Upper Cretaceous, Bavaria. [For *Siderolina cenomana* Schacko, in Egger, 1899.]
Haplophragmoides fraseri Wickenden, **302,** 86, pl. 1, fig. 2. Upper Cretaceous, Canada.
——— *heathensis* Berry, **19,** 26, pl. 2, figs. 11–13. Upper Oligocene, Peru.

——— *hetha* Berry, **19,** 26, pl. 3, figs. 10–12. Upper Oligocene, Peru.
——— *kirki* Wickenden, **302,** 85, pl. 1, fig. 1. Upper Cretaceous, Canada.
Helicolepidina august-tobleri Berry, **20,** 8, text fig. 1. Upper Eocene, Peru.
——— *polygyralis* Barker, **16,** 309, pl. 22, fig. 5. Upper Eocene, Ecuador.
Hemigordius harltoni Cushman and Waters, 1928, var. *germanica* Liebus, **182,** 153, pl. 10, fig. 10. Lower Carboniferous, Germany.
Heterostegina bantamensis Tan, **272,** 135, pl. 1, figs. 1–3, 10; pl. 2, fig. 3; pl. 4, fig. 3. Lower Oligocene, South Bantam, Java.
——— *praecursor* Tan, **272,** 133, pl. 1, figs. 4–6; pl. 2, figs. 1, 2; pl. 4, figs. 2, 4, 7; pl. 5, fig. 5. Lower Oligocene, South Bantam, Java.
——— sp. indet. Whipple, **299,** 83, pl. 20, fig. 9. Eocene, Eua, Tonga.
Heterostomella boynensis Wickenden, **302,** 89, pl. 1, fig. 5. Upper Cretaceous, Canada.
——— *cuneata* Sandidge, **238,** 269, pl. 41, figs. 11, 15, 16. Upper Cretaceous, Alabama.
Hippocrepinella nov. gen., Heron-Allen and Earland, **140,** 257. Fam. Astrorhizidae. Recent, South Atlantic. Genotype: *H. hirudinea* Heron-Allen and Earland, 1932.
——— *alba* Heron-Allen and Earland, **140,** 259, pl. 1, figs. 16–18. Recent, South Atlantic.
——— *hirudinea* Heron-Allen and Earland, **140,** 258, pl. 1, figs. 7–15. Recent, South Atlantic.
——— ——— ——— ——— 1932, var. *crassa* Heron-Allen and Earland, **140,** 259, pl. 2, figs. 1–3. Recent, South Atlantic.
Hopkinsina nov. gen., Howe and Wallace, **149,** 61. Fam. Buliminidae. Upper Eocene, Louisiana. Genoholotype: *H. danvillensis*, Howe and Wallace, 1932.
——— *danvillensis* Howe and Wallace, **149,** 62, pl. 12, fig. 1. Upper Eocene, Louisiana.
Hyperammina clavigera Heron-Allen and Earland, **141,** 332, pl. 7, figs. 12–15. Recent Falkland Islands.
——— *malovensis* Heron-Allen and Earland, **141,** 333, pl. 8, figs. 12–14. Recent, Falkland Islands.
Isolepidina, see *Lepidocyclina*.
Katacycloclypeus subgen. nov., Tan, **272,** 39. Fam. Cycloclypeidae. Tertiary Java. Subgenoholotype: *Cycloclypeus annulatus* Martin, 1879–80. See *Cycloclypeus*.
Lagena bicarinata (Terquem, 1882) var. *occlusa* Heron-Allen and Earland, **141,** 380, pl. 11, figs. 23–28. Recent, Falkland Islands.
——— *bisulcata* Heron-Allen and Earland, **141,** 380, pl. 11, figs. 29–32. Recent, Falkland Islands.
——— *digitale* Heron-Allen and Earland, **141,** 371, pl. 10, figs. 28–30. Recent, Falkland Islands.
——— *lanceolata* Paalzow, **205,** 133, pl. 9, fig. 28. Jurassic, Argovian, Germany. (This species name is preoccupied by Herrmann, 1917.)
——— *laureata* Heron-Allen and Earland, **141,** 382, pl. 11, figs. 37–40. Recent, Falkland Islands.
——— *nodosaroides* Paalzow, **205,** 133, pl. 9, fig. 29. Jurassic, Argovian, Germany.
——— *ouachitaensis* Howe and Wallace, **149,** 29, pl. 6, fig. 9. Upper Eocene, Louisiana.
——— *pleniluna* Howe and Wallace, **149,** 29, pl. 6, fig. 5. Upper Eocene, Louisiana.
——— *polygona* Paalzow, **205,** 133, pl. 9, fig. 27. Jurassic, Argovian, Germany.
——— *quadrata* (Williamson, 1858) var. *bispinosa* Heron-Allen and Earland, **141,** 375, pl. 11, figs. 1, 2. Recent, Falkland Islands.
——— *revertens* Heron-Allen and Earland, **141,** 380, pl. 11, figs. 23–28. Recent, Falkland Islands.
——— sp. (?) Cushman and Ponton, **75,** 60, pl. 7, fig. 22. Eocene, Alabama.
——— sp. (A) Howe and Wallace, **149,** 30, pl. 6, fig. 12. Upper Eocene, Louisiana.
——— sp. (B) Howe and Wallace, **149,** 30, pl. 6, fig. 10. Upper Eocene, Louisiana.
——— sp. (C) Howe and Wallace, **149,** 31, pl. 6, fig. 6. Upper Eocene, Louisiana.
——— sp. (D) Howe and Wallace, **149,** 31, pl. 6, fig. 7. Upper Eocene, Louisiana.
——— *uncinata* Heron-Allen and Earland, **141,** 375, pl. 11, fig. 3. Recent, Falkland Islands.
Lenticulina biformis Paalzow, **205,** 103, pl. 6, fig. 8. Jurassic, Argovian, Germany.
——— *dubia* Paalzow, **205,** 103, pl. 6, figs. 15, 18, 19. Jurassic, Argovian, Germany. [For *Cristellaria crepidula* ? var. ? Haeusler, 1890.] (This species should not be confused

with *Robulus dubius* (Seguenza, 1880).)
——— *jonesi* Sandidge, **238,** 273, pl. 42, figs. 1, 2. Upper Cretaceous, Alabama.
——— sp. Howe and Wallace, **149,** 32, pl. 7, fig. 2. Upper Eocene, Louisiana.
——— *staufensis* Paalzow, **205,** 102, pl. 6, fig. 7. Jurassic, Argovian, Germany.
Lepidocyclina arcuata Scheffen, **246,** 27, pl. 2, fig. 4. Miocene, west Java.
——— *ariena* Berry, **20,** 5, text fig. 6. Upper Eocene, Peru.
——— (*Lepidocyclina*) *asterodisca* Nuttall, **202,** 34, pl. 7, figs. 5, 8; pl. 9, fig. 10. Lower Oligocene, Mexico.
——— *callosa* Scheffen, **246,** 41, pl. 11, figs. 1–5. Miocene, west Java.
——— (*Lepidocyclina*) *canellei* Lemoine and R. Douvillé, 1904, var. *hieronymi* M. G. Rutten and Vermunt, **233,** 234, pl. 1, fig. 3; pl. 2, fig. 10. Upper Eocene, Curaçao.
——— *dehiscens* Scheffen, **246,** 23, pl. 2, figs. 1–2. Miocene, west Java.
——— *delicata* Scheffen, **246,** 18, pl. 1, fig. 4. Miocene, west Java. (The species name is already preoccupied by *L. delicada* Berry, 1929.)
——— *falconensis* Gorter and van der Vlerk, **128,** 105, pl. 11, figs. 4–6. Oligocene, Venezuela.
——— *gritta* Berry, **20,** 4, text fig. 9. Upper Eocene, Peru.
——— (*Nephrolepidina*) *hamiltonensis* Chapman and Crespin, **46,** 93, pl. 12, figs. 8–10. Lower Miocene, Western Victoria, Australia. [For *L. martini* Chapman, 1910, non Schlumberger, 1900.]
——— (*Nephrolepidina*) *howchini* Chapman and Crespin, **46,** 94, pl. 13, figs. 18, 19. Lower Miocene, Western Australia. [For ?*Orbitoides stellata* Howchin, 1889, non d'Archiac, 1846.]
——— (*Multilepidina*) *irregularis* Hanzawa, **133,** 448, text figs. 1–6. Burdigalian, Kaizan beds, Taiwan, Formosa.
——— (*Lepidocyclina*) *kugleri* Gorter and van der Vlerk, **128,** 106, pl. 11, figs. 7, 8; pl. 12, figs. 1–3. Upper Eocene, Venezuela.
——— *ocha* Berry, **20,** 4, text fig. 4. Upper Eocene, Peru.
——— (*Lepidocyclina*) *pancanalis* Vaughan and Cole, **293,** 510, text figs. 1–9. Middle-upper Oligocene, Chattian, Panama Canal Zone.
——— *pilifera* Scheffen, **246,** 29, pl. 4, figs. 2, 3. Miocene, central Java.
——— *robusta* Scheffen, **246,** 28, pl. 4, fig. 1. Miocene, west Java.
——— *rutteni* van der Vlerk, 1924, forma *globosa* Scheffen, **246,** 40, pl. 10, figs. 1–3. Miocene, Java.
——— ——— —— —— forma *stellata* Scheffen, **246,** 39, pl. 10, fig. 4. Miocene, Java.
——— *samanica* Berry, **20,** 3, text fig. 10. Upper Eocene, Peru.
——— (*Lepidocyclina*) *schotborghi* M. G. Rutten and Vermunt, **233,** 236, pl. 1, figs. 14, 15; pl. 3, figs. 5, 7. Upper Eocene, Curaçao.
——— *sectionensis* Berry, **20,** 3, text fig. 11. Upper Eocene, Peru.
——— *seis* Berry, **20,** 5, text fig. 3. Upper Eocene, Peru.
——— *senni* Gorter and van der Vlerk, **128,** 109, pl. 14, figs. 1–4. Oligocene, Venezuela.
——— sp. indet. Gorter and van der Vlerk, **128,** 110, pl. 16, fig. 1. Oligocene, Venezuela.
——— (*Isolepidina*) sp. M. G. Rutten and Vermunt, **233,** (no description), pl. 2, fig. 4; pl. 3, fig. 1. Upper Eocene, Curaçao.
——— *spatiosa* Scheffen, **246,** 39, pl. 9, figs. 1–3. Miocene, west Java.
——— *stigteri* van der Vlerk 1925 var. *lensiformis* Scheffen, **246,** 44, pl. 13, fig. 1. Miocene, west Java.
——— *stillafera* Scheffen, **246,** 17, pl. 1, fig. 2. Miocene, west Java.
——— (*Polylepidina*) *vanslobbeni* M. G. Rutten and Vermunt, **233,** 238, pl. 1, fig. 11; pl. 2, fig. 9; pl. 3, figs. 3, 4. Upper Eocene, Curaçao.
——— *verrucosa* Scheffen, **246,** 33, pl. 7, figs. 2–4. Miocene, west Java.
——— *volucris* Scheffen, **246,** 17, pl. 1, fig. 3. Miocene, Java.
Lepidocyclinidae fam. nov., Scheffen, **248,** pp. 251, 252.
Lingulina falcata Heron-Allen and Earland, **141,** 386, pl. 12, figs. 6–8. Recent, Falkland Islands.
——— sp. (?) Cushman and Ponton, **76,** 60, pl. 12, fig. 13. Upper Miocene, Florida.
——— *translucida* Heron-Allen and Earland,

141, 387, pl. 12, figs. 9–11. Recent, Falkland Islands.
——— *trilobata* Scheffen, **247,** 195, pl. figs. 1–2. Miocene, Java.
——— *vitrea* Heron-Allen and Earland, **141,** 387, pl. 12, figs. 12–14. Recent, Falkland Islands.
——— *wilcoxensis* Cushman and Ponton, **75,** 58, pl. 7, fig. 14. Eocene, Alabama.
Loftusia bemmeleni Silvestri, **260,** 89, pl. 3, fig. 5; pl. 4, figs. 1–4. Lower Cretaceous, Sumatra.
Lockhartia nov. gen., Davies, **81,** 403, 406 et seq. Fam. Chapmaniidae. Paleocene, Ranikot series India. Genotype: *Dictyconoides haimei* Davies, 1927.
Loxostomum cushmani Wickenden, **302,** 91, pl. 1, fig. 6. Upper Cretaceous, Canada.
——— *wilcoxensis* Cushman and Ponton, **75,** 67, pl. 9, fig. 3. Eocene, Alabama.
Marginulina alazanensis Nuttall, **202,** 13, pl. 3, figs. 3, 7. Lower Oligocene, Mexico.
——— *frankeana* Paalzow, **205,** 108, pl. 7, fig. 3. Jurassic, Argovian, Germany.
——— *pseudohirsuta* Nuttall, **202,** 13, pl. 3, figs. 1, 2. Lower Oligocene, Mexico. [For *Nodosaria aculeata* Cushman, 1927, non d'Orbigny, 1846.]
——— sp. Nuttall, **202,** 13, pl. 3, fig. 4. Lower Oligocene, Mexico.
——— sp. (A) Howe and Wallace, **149,** 34, pl. 7, fig. 3. Upper Eocene, Louisiana.
——— sp. (B) Howe and Wallace, **149,** 35, pl. 3, fig. 5. Upper Eocene, Louisiana.
——— sp. (C) Howe and Wallace, **149,** 35, pl. 3, fig. 6. Upper Eocene, Louisiana.
——— *stuifensis* Paalzow, **205,** 108, pl. 7, fig. 5. Jurassic, Argovian, Germany.
——— *triangularis* d'Orbigny, 1846, var. *danvillensis* Howe and Wallace, **149,** 34, pl. 5, fig. 6. Upper Eocene, Louisiana.
Massilina australis Cushman, **69,** 32, pl. 8, fig. 2. Recent, tropical Pacific.
——— *gunteri* Cushman and Ponton, **76,** 47, pl. 4, fig. 1. Upper Miocene, Florida.
——— *humblei* Cushman and Ellisor, **72,** 40, pl. 6, fig. 1. Upper Eocene, Texas.
——— *incisa* Cushman and Ponton, **76,** 47, pl. 4, figs. 2–6. Lower Miocene, Florida.
——— *planata* Cushman, **69,** 31, pl. 8, fig. 3. Recent, tropical Pacific.
——— *quadrans* Cushman and Ponton, **76,** 47, pl. 3, figs. 6–8. Lower Miocene, Florida.
——— *spinata* Cushman and Ponton, **76,** 48, pl. 5, figs. 1–3. Lower Miocene, Florida.
——— ——— ——— ——— 1932, var. *chipolensis* Cushman and Ponton, **76,** 48, pl. 5, figs. 4–6. Lower Miocene, Florida.
——— ——— ——— ——— 1932, var. *glabrata* Cushman and Ponton, **76,** 49, pl. 5, fig. 7. Lower Miocene, Florida.
Miliammina manitobensis Wickenden, **302,** 90, pl. 1, fig. 11. Upper Cretaceous, Canada.
Miliolina sp. van Rijsinge, **229,** 21, pl. 1, figs. 18–20. Paleocene, southeastern Holland.
Miogypsinoides dehaartii (van der. Vlerk, 1924) var. *nitidula* Chapman, **44,** 491, 492, pl. 63, figs. 1, 2. Lower Miocene, New Zealand.
Multilepidina subgen. nov., Hanzawa, **133,** 447. Fam. Orbitoididae. Miocene, Burdigalian, Taiwan, Formosa. Subgenoholotype: *Lepidocyclina* (*Multilepidina*) *irregularis* Hanzawa, 1932. See *Lepidocyclina*.
Nephrolepidina, see *Lepidocyclina*.
Nodobacularia antillarum (Cushman, 1922) var. *pacifica* Cushman, **69,** 68, pl. 16, fig. 1. Recent, tropical Pacific.
——— *bulbifera* Paalzow, **205,** 96, pl. 5, figs. 4–6. Jurassic, Argovian, Germany.
——— *millettii* Cushman, **69,** 69, pl. 16, figs. 3, 4. Recent, tropical Pacific. [For *Articulina conicoarticulata* Millett, 1898, non Batsch, 1791.]
Nodosaria batschi Thalmann nov. sp., for *Nautilus* (*O.*) *radicula* Batsch, 1791; in Cushman, 1931, Contr. Cushman Lab. Foram. Research, vol. 7, p. 63, pl. 9, fig. 5. Recent, Adriatic.
——— *limbata* d'Orbigny, 1840, var. *basiornata* Cushman and Jarvis, **73,** 32, pl. 10, figs. 7, 8. Upper Cretaceous, Trinidad.
——— ——— ——— var. *tumidata* Cushman and Jarvis, **73,** 32, pl. 10, fig. 6. Upper Cretaceous, Trinidad.
——— *schwageri* Paalzow, **205,** 124, pl. 9, fig. 6. Jurassic, Argovian, Germany. (The species name is preoccupied by Rzehak, 1888.)
Nonion applini Howe and Wallace, **149,** 51, pl. 9, fig. 4. Upper Eocene, Louisiana.
——— *cretaceum* Cushman and Jarvis, **73,** 41, pl. 12, fig. 12. Upper Cretaceous,

Trinidad. [The species name is preoccupied by Schlumberger, 1899, and has been changed to *N. jarvisi* nom. nov. Thalmann, 1932.]

——— *danvillensis* Howe and Wallace, **149,** 51, pl. 9, fig. 3. Upper Eocene, Louisiana.

——— *hantkeni* (Cushman and Applin, 1926) var. *fayettei* Cushman and Ellisor, **72,** 41, pl. 6, fig. 3. Upper Eocene, Louisiana.

——— *jarvisi* Thalmann, **281,** 313. For *N. cretaceum* Cushman and Jarvis, 1932, ut supra. Upper Cretaceous, Trinidad.

——— *manpukuziensis* Ôtuka, **204,** 641–655, fig. (Mon vidi).

——— *scapha* (Fichtel and Moll, 1798) var. *inflatum* Cushman and Ellisor, **72,** 41, pl. 6, fig. 2. Upper Eocene, Louisiana.

——— sp. Howe and Wallace, **149,** 25, pl. 9, fig. 1. Upper Eocene, Louisiana.

——— *stelligerum* (d'Orbigny, 1839) var. nov. Thalmann, **280,** 311. Recent, Ascension Island.

——— *wilcoxensis* Cushman and Ponton, **75,** 64, pl. 8, fig. 11. Eocene, Alabama.

Nonionella alabamensis Cushman and Ponton, **75,** 65, pl. 8, fig. 15. Eocene, Alabama.

——— *danvillensis* Howe and Wallace, **149,** 52, pl. 9, fig. 5. Upper Eocene, Louisiana.

——— *iridea* Heron-Allen and Earland, **141,** 438, pl. 16, fig. 14–16. Recent, Falkland Islands.

——— *wilcoxensis* Cushman and Ponton, **75,** 65, pl. 8, fig. 12. Eocene, Alabama.

Nubeculina chapmani Cushman, **69,** 49, pl. 11, fig. 7. Recent, tropical Pacific. [For *N. divaricata* Chapman, 1901, non Brady, 1879.]

Nubeculinella filiformis Paalzow, **205,** 97, pl. 5, fig. 3. Liassic, Germany.

Nummulites vanderstoki M. G. Rutten and Vermunt, **233,** 240, pl. 1, fig. 8; pl. 2, figs. 6, 12. Upper Eocene, Curaçao.

——— see *Camerina*. (Gerth, **124,** published several nomina nuda for *Nummulites*, which later were described under *Camerina* by Doornink, **94.**)

Nummulostegina sp. sp. Liebus, **182,** 170, pl. 10, figs. 13–16, 32. Lower Carboniferous, Germany.

Operculina atascaderensis Berry, 1930, var. *samanica* Berry, **20,** 8, text fig. 5. Upper Eocene, Peru.

——— *catenulata* Cushman and Jarvis, **73,** 42, pl. 12, fig. 13. Upper Cretaceous, Trinidad.

——— *curasavica* M. G. Rutten and Vermunt, **233,** 239, pl. 2, figs. 2, 11. Upper Eocene, Curacao.

——— *pacifica* Whipple, **299,** 83, pl. 20, figs. 1, 8. Eocene, Eua, Tonga.

——— *samanica* Berry, **20,** 9, text fig. 2. Upper Eocene, Peru.

——— *talara* Berry, **20,** 9, text fig. 8. Upper Eocene, Peru.

Patellina corrugata Williamson, 1858, var. *formosa* Heron-Allen and Earland, **141,** 406, pl. 13, figs. 23–25. Recent, Falkland Islands.

Patellinoides nov. gen., Heron-Allen and Earland, **141,** 407. Fam. Rotaliidae. Recent, Falkland Islands area. Genotype: *P. conica* Heron-Allen and Earland, 1932.

——— *conica* Heron-Allen and Earland, **141,** 408, pl. 13, figs. 26–29. Recent, Falkland Islands.

——— *depressa* Heron-Allen and Earland, **141,** 408, pl. 13, figs. 30–33. Recent, Falkland Islands.

Pavonina miocenica Cushman and Ponton, **76,** 73, pl. 12, fig. 19. Upper Miocene, Florida.

Pellatispira fulgeria Whipple, **299,** 82, pl. 20, figs. 2–4, 6, 7. Eocene, Eua, Tonga.

——— *hoffmeisteri* Whipple, **299,** 82, pl. 20, fig. 5; pl. 21, figs. 4, 5. Eocene, Eua, Tonga.

Pelosphaera nov. gen., Heron-Allen and Earland, **140,** 255. Fam. Astrorhizidae. Recent, South Atlantic. Genotype: *P. cornuta* Heron-Allen and Earland, 1932.

——— *cornuta* Heron-Allen and Earland, **140,** 255, pl. 2, figs. 12–15. Recent, South Atlantic.

Planularia advena Cushman and Jarvis, **73,** 24, pl. 8, figs. 1, 2. Upper Cretaceous, Trinidad.

——— *cassis* (Fichtel and Moll, 1798), nov. var. Thalmann, **280,** 305. Recent, Fiji.

——— *catahoulaensis* Howe and Wallace, **149,** 36, pl. 3, figs. 3, 4. Upper Eocene, Louisiana.

——— *danvillensis* Howe and Wallace, **149,** 36, pl. 3, fig. 1. Upper Eocene, Louisiana.

——— *feifeli* Paalzow, **205,** 105, pl. 6, figs. 11, 12. Jurassic, Argovian Germany.

——— n. sp. aff. *Cristellaria compressa* Brady, 1884, non d'Orbigny, 1846; n. sp. aff. Thalmann, **280,** 312. Recent Faroe Channel, North Atlantic.

——— n. sp. aff. *Cristellaria dentata* Brady 1884, non Karrer, 1867; n. sp. aff. Thalmann, **280,** 311. Recent, Fiji, Pacific.

——— n. sp. aff. *Cristellaria lata* Brady, 1884, non Cornuel, 1848; n. sp. aff. Thalmann, **280,** 305. Recent, Bass Strait, Australia.

——— *ouachitaensis* Howe and Wallace, **149,** 37, pl. 3, fig. 7. Upper Eocene, Louisiana.

Planulina alazanensis Nuttall, **202,** 31, pl. 8, figs. 4, 8, 9. Lower Oligocene Mexico.

——— *biconcava* (Jones and Parker, 1865), var. *planoconcava* Parr and Collins, ms., in Parr, **207,** 232, pl. 22, fig. 34. Oligocene and Recent, Australia.

Polylepidina, see *Lepidocyclina*.

Polystomella, see *Elphidium*.

Polytrema sp. van Rijsinge, **229,** 54, pl. 4, figs. 12–19. Paleocene, southeastern Holland.

Proteonina compressa Paalzow, **205,** 90, pl. 6, figs. 2, 3. Jurassic, Argovian, Germany.

——— *spiculifera* Parr, **206,** 2, pl. 1, fig. 1. Recent, Victoria, Australia.

Psammatodendron indivisum Heron-Allen and Earland, **141,** 334, pl. 7, fig. 16. Recent, Falkland Islands.

Psammosphaera micrograna Eisenack, **109,** 261, pl. 11, fig. 19. Silurian, Baltic Provinces.

Pseudastrorhiza nov. gen., Eisenack, **109,** 259. Fam. Saccamminidae. Silurian, Baltic Provinces. Genotype: *P. silurica* Eisenack, 1932.

——— *silurica* Eisenack, **109,** 259, pl. 11, figs. 1–6. Silurian, Baltic Provinces.

Pseudodoliolina nov. gen., Yabe and Hanzawa, **306,** 41. Fam. Fusulinidae. Carboniferous, Indo-China. Genotype: *P. ozawai* Yabe and Hanzawa, 1932.

——— *ozawai* Yabe and Hanzawa, **306,** 41. Carboniferous, Uralian, Japan, Indo-China.

Pseudoglandulina sp. (?) Cushman and Jarvis, **73,** 37, pl. 11, fig. 13. Upper Cretaceous, Trinidad.

Pseudopolymorphina ozawana Cushman and Jarvis, **73,** 41, pl. 12, fig. 9. Upper Cretaceous, Trinidad.

——— *wilcoxensis* Cushman and Ponton, **75,** 61, pl. 8, figs. 5, 6. Eocene, Alabama.

Pseudorbitoides israelskii Vaughan and Cole, **292,** 614, pl. 2, figs. 1–7. Upper Cretaceous, Louisiana.

Pseudouvigerina wilcoxensis Cushman and Ponton, **75,** 66, pl. 8, fig. 18. Eocene, Alabama.

Pulvinulinella danvillensis Howe and Wallace, **149,** 71, pl. 13, fig. 7. Upper Eocene, Louisiana.

——— *ripleyensis* Sandidge, **236,** 315, pl. 29, figs. 7–9. Upper Cretaceous Alabama.

Pyrgo inornata (d'Orbigny, 1826) var. *danvillensis* Howe and Wallace, **149,** 21, pl. 2, fig. 1. Upper Eocene, Louisiana.

Quinqueloculina ammophila Parr, **206,** 8, pl. 1, fig. 10; text fig. 1-E. Recent, Australia.

——— *australis* Parr, **206,** 7, pl. 1, fig. 8. Recent, Tasmania, Victoria, etc. [For *Miliolina subrotunda* Brady, 1884, non *Vermiculum subrotundum* Montagu, 1803.]

——— *chipolensis* Cushman and Ponton, **76,** 45, pl. 3, figs. 1–3. Lower Miocene, Florida.

——— *crenulata* Cushman, **69,** 21, pl. 5, fig. 11. Recent, tropical Pacific.

——— *danvillensis* Howe and Wallace, **149,** 22, pl. 2, fig. 2. Upper Eocene, Louisiana.

——— *semireticulosa* Cushman, **69,** 27, pl. 7, fig. 2. Recent, tropical Pacific.

——— *striatula* Cushman, **69,** 27, pl. 7, figs. 3, 4. Recent, tropical Pacific.

Radiocycloclypeus subgen. nov., Tan, **272,** 92. Fam. Cycloclypeidae. Upper Tertiary, Dutch East Indies. Subgenoholotype: *Cycloclypeus* (*Radiocycloclypeus*) *stellatus* Tan, 1932. See *Cycloclypeus*.

Ramulinella nov. gen., Paalzow, **205,** 135. Fam. Polymorphinidae. Jurassic, Argovian, Germany. Genotype: *R. suevica* Paalzow, 1932.

——— *suevica* Paalzow, **205,** 135, pl. 11, fig. 5. Jurassic, Argovian, Germany.

Rectocibicides nov. gen., Cushman and Ponton, **74,** 2. Fam. Rotaliidae. Miocene Florida. Genotype: *R. miocenicus* Cushman and Ponton, 1932.

——— *miocenicus* Cushman and Ponton, **74,** 2, pl. 1, figs. 5–7. Miocene, Florida.

Rectogumbelina nov. gen., Cushman, **61,** 6. Fam. Heterohelicidae. Upper Cretaceous,

Arkansas. Genotype: *R. cretacea* Cushman, 1932.

——— *cretacea* Cushman, **61,** 6, pl. 1, figs. 11, 12. Upper Cretaceous, Arkansas.

——— *texana* Cushman, **61,** 6, pl. 1, figs. 8–10. Upper Cretaceous, Texas.

Reophax cushmani Heron-Allen and Earland, **141,** 339, pl. 7, figs. 22–24. Recent, Falkland Islands. [For *R. advena* Heron-Allen and Earland, 1922, non Cushman, 1919.]

——— *friabilis* Parr, **206,** 3, pl. 1, fig. 2; text fig. 1-*a*. Recent, Victoria, Australia.

Reussia armata Parr, **207,** 224, pl. 22, figs. 49, 50. Recent, South Australia.

Rhabdogonium suprajurassicum Paalzow, **205,** 125, pl. 9, fig. 7. Jurassic, Argovian, Germany.

Robertina wilcoxensis Cushman and Ponton, **75,** 66, pl. 8, fig. 19. Eocene, Alabama.

Robulus aldrichi Sandidge, **238,** 272, pl. 42, figs. 3, 4. Upper Cretaceous, Alabama.

——— *alexanderi* Sandidge, **236,** 313, pl. 29, figs. 1, 2. Upper Cretaceous Alabama.

——— (?) *danvillensis* Howe and Wallace, **149,** 39, pl. 5, fig. 7. Upper Eocene, Louisiana. [For *R. mexicanus* (Cushman, 1927) non *Cristellaria mexicana* Cushman, 1925.]

——— n. sp. aff. *Cristellaria crepidula* Brady, 1884, non Fichtel and Moll, 1798; n. sp. aff. Thalmann, **280,** 305. Recent, Kei-Islands.

——— n. sp. aff. *Cristellaria* sp. Brady, 1884; n. sp. aff. Thalmann, **280,** 305. Recent, Atlantic, southwest of Ireland.

——— *trinitatensis* Cushman and Jarvis, **73,** 22, pl. 6, fig. 10. Upper Cretaceous, Trinidad.

——— *wilcoxensis* Cushman and Ponton, **75,** 52, pl. 7, fig. 3. Eocene, Alabama.

Rotalia mexicana Nuttall, 1928, var. *mecatepecensis* Nuttall, **202,** 26, pl. 4, figs. 11, 12. Lower Oligocene, Mexico.

——— sp. van Rijsinge, **229,** pl. 4, figs. 1–7. Paleocene, southeastern Holland.

——— *trochidiformis* Lamarck, 1804, var. *hautevillensis* Davies, **81,** 418, pl. 4, figs. 1, 2, 8. Middle Eocene, France.

Spiroloculina antillarum d'Orbigny, 1839, var. *aequa* Cushman, **69,** 38, pl. 9, fig. 13. Recent, tropical Pacific.

——— *clara* Cushman, **69,** 40, pl. 10, figs. 4, 5. Recent, tropical Pacific.

——— *grateloupi* d'Orbigny, 1826, var. *acescata* Cushman, **69,** 35, pl. 9, fig. 2. Recent, tropical Pacific. [For *S. canaliculata* Cushman, 1925, non d'Orbigny, 1826.]

——— ——— ——— var. *serrulata* Cushman, **69,** 35, pl. 9, fig. 1. Recent, tropical Pacific.

——— *tenuirostra* Karrer, 1867, var. nov. Thalmann, **280,** 297. Recent.

Spirophthalmidium miliolinifórme Paalzow, **205,** 100, pl. 5, figs. 14–19. Jurassic, Argovian, Germany.

——— *stuifense* Paalzow, **205,** 100, pl. 5, figs. 21, 22. Jurassic, Argovian, Germany.

——— *tenuissimum* Paalzow, **205,** 100, pl. 5, figs. 11–13. Jurassic, Argovian, Germany.

Spiroplectammina laevis (Römer, 1840) var. *cretosa* Cushman, **66,** 87, pl. 11, fig. 3. Upper Cretaceous, Texas. [For *Spiroplectammina semicomplanata* (Carsey,1926) in Plummer, pars (pl. 8, fig. 8) 1931.]

——— *mordensis* Wickenden, **302,** 86, pl. 1, fig. 4. Upper Cretaceous, Canada.

——— *navarroana* Cushman, **66,** 96, pl. 11, fig. 14. Upper Cretaceous, Texas.

——— n. sp. aff. *Spiroplecta americana* Brady, 1884, non Ehrenberg, 1843; n.sp. aff. Thalmann, **280,** 301. Recent, Bass Strait, Australia.

——— *semicomplanata* (Carsey, 1926) var. *juncea* Cushman, **66,** 95, pl. 11, fig. 10. Upper Cretaceous, Arkansas.

——— *wilcoxensis* Cushman and Ponton, **75,** 51, pl. 7, fig. 1. Eocene, Alabama.

Sumatrina gemmellaroi Silvestri, **259,** 260. (No fig.) Permian, Sicily.

Saccammina (?) *fabianii* Silvestri, **259,** 260. (No fig.) Permian, Sicily.

Saracenaria danvillensis Howe and Wallace, **149,** 41, pl. 4, fig. 3. Upper Eocene, Louisiana.

——— *dubia* Paalzow. **205,** 126, pl. 9, figs. 9, 10. Jurassic, Argovian, Germany.

——— *moresiana* Howe and Wallace, **149,** 42, pl. 2, fig. 8. Upper Eocene, Louisiana.

——— *wilcoxensis* Cushman and Ponton, **75,** 54, pl. 7, fig. 9. Eocene, Alabama.

Schackoina subgen. nov., Thalmann, **279,** 289. Fam. Nonionidae. Upper Cretaceous, Germany. Subgenotype: *Siderolina cenomana* Schacko, 1896= *Hantkenina* (*Schackoina*) *cenomana* (Schacko, 1896). See *Hantkenina*.

Schellwienia ozawai Iisaka, **152,** 1–4, text figs. 1–4. Permian, Mino Province, Japan.
Schwagerina gigantea White, **300,** 82, pl. 8, figs. 13–15. Pennsylvanian, Texas.
Siderolites heracleae Arni, **10,** 199–221, pls. 8–10, text figs. 2–4. Upper Cretaceous, Senonian, Black Sea, Asia Minor.
Sigmoidella elegantissima (Parker and Jones, 1865) nov. var. Thalmann, **280,** 306, Recent, Kei-Islands.
Sigmoilina obesa Heron-Allen and Earland, **141,** 320, pl. 7, figs. 1–4. Recent, Falkland Islands.
Sigmomorphina alabamensis Cushman and Ponton, **75,** 62, pl. 8, fig. 8. Eocene, Alabama.
——— *wilcoxensis* Cushman and Ponton, **75,** 61, pl. 8, fig. 7. Eocene, Alabama.
Siphonina carltoni Cushman and Ellisor, **72,** 42, pl. 6, fig. 5. Upper Eocene, Louisiana.
——— *danvillensis* Howe and Wallace, **149,** 70, pl. 13, fig. 1. Upper Eocene, Louisiana.
Sorites (?) sp. (?) Cushman and Ponton, **76,** 72, pl. 17, figs. 1–8. Lower Miocene, Florida.
Sphaeroidina peruviana Berry, **19,** 29, pl. 2, fig. 4. Upper Oligocene, Peru.
Spirocyclina choffati Munier-Chalmas, 1887, var. *euxina* Charles, **52,** 472, pl. 27, Jurassic, Portlandian, Asia Minor.
Technitella nitida Heron-Allen and Earland, **141,** 328, pl. 16, fig. 39. Recent, Falkland Islands.
Tetrataxis sp. Liebus, **182,** 164, pl. 9, fig. 31. Lower Carboniferous, Germany.
Textularia bigenerinoides Lacroix, **178,** 24, text. figs. 27–31. Recent, Mediterranean Sea.
——— *broussardi* Howe and Wallace, **149,** 18, pl. 1, fig. 3. Upper Eocene, Louisiana.
——— *cochleata* Lacroix, **178,** 27, text figs. 32, 33. Recent, Mediterranean Sea.
——— *danvillensis* Howe and Wallace, **149,** 18, pl. 1, figs. 2, 4. Upper Eocene, Louisiana.
——— *dentimarginata* Nuttall, **202,** 6, pl. 1, fig. 2. Lower Oligocene, Mexico.
——— *foliacea* Heron-Allen and Earland, 1915, var. *oceanica* Cushman, **69,** 8, pl. 1, figs. 11, 12. Recent, tropical Pacific.
——— *heathensis* Berry, **19,** 27, pl. 3, figs. 8, 9. Upper Oligocene, Peru.
——— *mississippiensis* Cushman, 1922, var. *alazanensis* Nuttall, **202,** 5, pl. 1, fig. 1. Lower Oligocene, Mexico.
——— *ouachitaensis* Howe and Wallace, **149,** 20, pl. 1, . 1. figUpper Eocene, Louisiana.
——— sp. Howe and Wallace, **149,** 20, pl. 1, fig. 6. Upper Eocene, Louisiana.
——— sp. (?) Cushman and Ponton, **76,** 42, pl. 1, fig. 7. Miocene, Florida.
Textulariella cretosa Cushman, **65,** 97, pl. 11, figs. 17–19. Cretaceous, England.
Tholosina protea Heron-Allen and Earland, **141,** 330, pl. 8, figs. 5–8. Recent, Falkland Islands.
Triloculina labiosa d'Orbigny, 1839, var. *sparsicostata* Cushman, **69,** 54, pl. 12, fig. 1. Recent, tropical Pacific.
——— *oceanica* Cushman, **69,** 54, pl. 12, fig. 3. Recent, tropical Pacific.
——— var. *flintiana* Cushman, **69,** 55, pl. 12, fig. 4. Recent, tropical Pacific.
——— *quadrilateralis* d'Orbigny, 1839, var. *longicostata* Cushman and Ponton, **76,** 53, pl. 7, fig. 2. Lower Miocene, Florida.
——— *spinata* Cushman, **69,** 56, pl. 12, fig. 5. Recent, tropical Pacific.
Triplasia wilcoxensis Cushman and Ponton, **75,** 58, pl. 7, fig. 19. Eocene, Alabama.
Tritaxia manitobensis Wickenden, **302,** 87, pl. 1, fig. 10. Upper Cretaceous, Canada.
Triticites compactus White, **300,** 38, pl. 2, figs. 10–12. Pennsylvanian, Texas.
——— ——— White, 1932, *var.*? White, **300,** 38, pl. 2, figs. 13–15. Pennsylvanian, Texas.
——— *consobrinus* Galloway and Ryniker, ms., in White, **300,** 41, pl. 2, figs. 16–18. Pennsylvanian, Texas.
——— sp. A. White, **300,** 78, pl. 8, figs. 1–3. Pennsylvanian, Texas.
——— sp. B. White, **300,** 79, pl. 8, figs. 4–6. Pennsylvanian, Texas.
——— *ventricosus* (Meek, 1858), var. *inflatus* Galloway and Ryniker, ms., in White, **300,** 74, pl. 7, figs. 10–12. Pennsylvanian, Texas.
Trochammina albertensis Wickenden, **302,** 90, pl. 1, fig. 9. Upper Cretaceous, Canada.
——— *glabra* Heron-Allen and Earland, **141,** 344, pl. 7, figs. 26–28. Recent, Falkland Islands.
——— *kellettae* Thalmann, **281,** 313. Recent,

west coast of South America. [For *T. peruviana* Cushman and Kellett, 1929, non Berry, 1928.]

——— *ribstonensis* Wickenden, **302,** 90, pl. 1, fig. 12. Upper Cretaceous, Canada.

Trocholina elevata Paalzow, **205,** 140, pl. 11, fig. 4. Jurassic, Argovian, Germany.

——— *feifeli* Paalzow, **205,** 140, pl. 11, figs. 6, 7. Jurassic, Argovian, Germany.

——— *transversarii* Paalzow, **205,** 141, pl. 11, figs. 8–10. Jurassic, Argovian, Germany.

Truncatulina heathensis Berry, **19,** 30, pl. 2, figs. 8–10. Upper Oligocene, Peru.

——— *hetha* Berry, **19,** 31, pl. 2, figs. 5–7. Upper Oligocene, Peru.

——— *praecincta* (Karrer, 1868) var. *depressa* Lipparini, **185,** 243, text fig. 2. Miocene, Italy.

——— *tenuimargo* Brady, 1884, var. *attenuata* Lipparini, **185,** 245, text fig. 3. Miocene, Italy.

——— *ungeriana* (d'Orbigny, 1846) var. *depressa* Lipparini, **185,** 243, text fig. 1. Miocene, Italy.

Tubulogerina eocenica Cushman and Ellisor, **72,** 42, pl. 6, fig. 4. Upper Eocene, Texas.

Turrilina angulata Sandidge, **235,** 198, pl. 19, figs. 7, 8. Upper Cretaceous, Alabama.

Turritellella neojurassica Paalzow, **205,** 93, pl. 4, fig. 17. Jurassic, Argovian, Germany.

Uvigerina alazanensis Nuttall, **202,** 22, pl. 5, fig. 10. Lower Oligocene, Mexico.

——— *angulosa* Williamson, 1858, var. *pauperata* Heron-Allen and Earland, **141,** 398, pl. 12, figs. 40–43. Recent, Falkland Islands.

——— *danvillensis* Howe and Wallace, **149,** 62, pl. 12, fig. 5. Upper Eocene, Louisiana.

——— *mediterranea* Hofker, **146,** 118, text fig. 32. Recent, Gulf of Naples. [For *U. pigmea* auctorum, non d'Orbigny, 1826.]

——— *mexicana* Nuttall, **202,** 22, pl. 5, figs. 12, 13. Lower Oligocene, Mexico.

——— *pygmaea* d'Orbigny, 1826, var. *uniseriata* Jedlitschka, **156,** 12, pl. fig. 15. Miocene, Czechoslovakia.

——— *spinicostata* Cushman and Jarvis, 1929, var. *alazanensis* Nuttall, **202,** 23, pl. 6, fig. 1. Lower Oligocene, Mexico.

Vaginulina alazanensis Nuttall, **202,** 17, pl. 1, figs. 11, 15. Lower Oligocene, Mexico.

——— *elegans* d'Orbigny, 1826, var. *mexicana* Nuttall, **202,** 16, pl. 3, figs. 12, 16. Lower Oligocene, Mexico.

——— *patteiskyana* Jedlitschka, **156,** 11, pl. fig. 17. Miocene, Czechoslovakia.

——— *vertebralis* Parr, **207,** 221, pl. 22, fig. 42. Recent, Victoria, Australia.

Valvulineria ripleyensis Sandidge, **238,** 281, pl. 43, figs. 4–6. Upper Cretaceous, Alabama.

——— *wilcoxensis* Cushman and Ponton, **75,** 70, pl. 9, fig. 6. Eocene, Alabama.

Ventilabrella plummerae Sandidge, **235,** 195, pl. 19, figs. 5, 6. Upper Cretaceous, Alabama.

——— sp. Howe and Wallace, **149,** 54, pl. 9, fig. 7. Upper Eocene, Louisiana.

Verneuilina bearpawensis Wickenden, **302,** 87, pl. 1, fig. 8. Upper Cretaceous, Canada.

——— *mexicana* Nuttall, **202,** 6, pl. 2, figs. 1, 2. Lower Oligocene, Mexico.

Virgulina danvillensis Howe and Wallace, **149,** 65, pl. 11, fig. 2. Upper Eocene, Louisiana.

——— *pontoni* Cushman, **62,** 17, pl. 3, fig. 7. Miocene, Florida. [For *V. floridana* Cushman and Laiming, 1931, non Cushman, 1920.]

——— (*Virgulinella*) *gunteri* Cushman, 1929, var. *curtata* Cushman and Ponton, **74,** 4, pl. 1, fig. 2; and **62,** 23, pl. 3, fig. 18. Miocene, Florida.

——— *schreibersiana* Czjzek, 1848, var. *spinosa* Heron-Allen and Earland, **141,** 352, pl. 9, figs. 3, 4. Recent, Falkland Islands.

——— *wilcoxensis* Cushman and Ponton, **75** 67, pl. 8, fig. 22. Eocene, Alabama.

Virgulinella subgen.nov., Cushman, **62,** 9. Fam. Buliminidae. Miocene, Germany, Florida. Subgenoholotype: *Virgulina pertusa* Reuss, 1860–61.

Vulvulina colei Cushman, **67,** 84, pl. 10, figs. 21, 22. Upper Eocene, Mexico. [For *V. advena* Cole, 1928, non Cushman, 1926.]

——— *jarvisi* Cushman, **67,** 84, pl. 10, fig. 20. Eocene, Trinidad.

——— *pacifica* Cushman, **67,** 78, pl. 10, figs. 8, 9. Recent, Philippines. [For *Bigenerina capreolus* Cushman, 1921, non d'Orbigny,

1826; and for *Bigenerina pennatula* Cushman, 1921, non Batsch, 1791.]

—— *pennatula* (Batsch, 1798) var. *italica* Cushman, **67,** 7, pl. 10, figs. 6, 7. Moicene, Italy. [For *Bigenerina pennatula* Fornasini, 1889, non Batsch, 1791.]

—— *spinosa* Cushman, 1927, var. *miocenica* Cushman, **67,** 80, pl. 10, fig. 10. Miocene, Jamaica. [For *V. capreolus* Cushman, 1929, non d'Orbigny, 1826; and for *V. capreolus* d'Orbigny, 1826, var. *spinosa* Nuttall, 1932.]

Webbinella depressa Heron-Allen and Earland, **141,** 329, pl. 7, figs. 10, 11. Recent, Falkland Islands.

PALEONTOLOGICAL NOTES

BAIRDIA SUBDELTOIDEA (MÜNSTER) IN THE AMERICAN TERTIARY

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Among the Ostracoda few species have been accorded a longer range than *Bairdia subdeltoidea* (Münster). In European literature it is commonly given a Cretaceous and Tertiary range. Alexander,[1] in his excellent paper on Cretaceous *Bairdias*, demonstrated that a number of closely related species could be distinguished from *B. subdeltoidea* and that each had stratigraphic value. In this paper, and in one which followed,[2] he considered that *B. subdeltoidea*, in its typical form, occurred in the Eagleford formation of Texas. Blake,[3] in a careful summary, demonstrated that Astrupp bei Osnabrück, in northwest Germany, should be considered the type locality of this species, and that it was in reality Tertiary in age, giving the name *Bairdia alexandrina* to the Eagleford species.

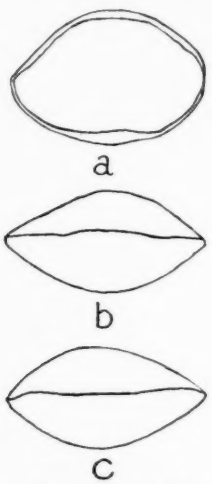

FIG. 1 *a, b, c.*—*Bairdia subdeltoidea* (Münster), a specimen from the Red Bluff Oligocene at the base of the bluff at Old Fort St. Stephens, Alabama. *a*, View of right valve. *b*, Ventral view. *c*, Dorsal view. All figures ×30.

Through the kindness of Dr. Joseph A. Cushman, the author has been able to examine ostracodes from the Oligocene of Astrupp. In the collection there was one well-preserved carapace of a *Bairdia*, which from its size and shape, the author feels certain is *Bairdia subdeltoidea*. Comparison of this carapace with specimens from numerous American Tertiary and Cretaceous localities quickly demonstrated that there was a species, identical in all external characters, present in the Red Bluff Oligocene beds at Old Fort St. Stephens, Alabama. The *Bairdias* present at other Tertiary localities appeared quite distinct either in outline, or in the character of overlap.

To make this species available to American workers on Tertiary Ostracoda, the writer has prepared outline drawings of a St. Stephens specimen. As the St. Stephens specimen was slightly larger than the one from Astrupp, the writer photographed the Astrupp specimen. The photographs were then en-

[1] Alexander, C. I., The stratigraphic range of the Cretaceous ostracode *Bairdia subdeltoidea* and its allies: *Jour. Paleontology*, vol. 1, pp. 29–33, 1 pl., 1927.

[2] Alexander, C. I., Ostracoda of the Cretaceous of North Texas: *Texas Univ., Bull.* 2907, pp. 61, 62, pl. 3, fig. 5, 1929.

[3] Blake, C. H., Notes on Ostracoda. 4. The age of *Bairdia subdeltoidea: Jour. Paleontology*, vol. 5, pp. 160–163, 1931.

larged to the same dimensions as the drawings and superimposed over them. In dorsal and ventral views, the outline and overlap proved to be identical to the minutest detail. In side view, the ratio of height to length and the amount and position of overlap corresponded, but the St. Stephens specimen showed a faintly narrower outline posteriorly, a condition not noticeable to the eye when the two specimens were placed side by side.

DESCRIPTION

BAIRDIA SUBDELTOIDEA (Münster)

Text figure 1*a*, *b*, *c*

Cythere subdeltoidea MÜNSTER, *1830*, Neues Jahrb. f. Min., etc., p. 64.
Cytherina subdeltoidea F. A. ROEMER, *1838*, Neues Jahrb. f. Min., etc., p. 517, pl. 6, fig. 16.
Bairdia subdeltoidea BLAKE, *1931*, Jour. Paleontology, vol. 5, p. 162.

Carapace in side view subtriangular; height approximately two-thirds the length. Greatest height of carapace about the middle. Greatest width slightly behind the middle. Left valve larger than and overlapping the right valve; the greatest overlap being along the middle one-third of the ventral margin, and slightly less so along the dorsal margin; least overlap at the anterior and posterior ends.

Length 0.96 mm.; height 0.64 mm.; thickness 0.48 mm.

Plesiotype: Howe collection, Louisiana State University, No. 747, Red Bluff Oligocene, Old Fort St. Stephens, Alabama.

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